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# ANCIENT SEA-MARGINS,

AS MEMORIALS OF CHANGES

IN THE RELATIVE LEVEL OF SEA AND LAND

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By ROBERT CHAMBERS, Esq., F.R.S.E.

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MAP OF
PART OF LOCHABER
SHOWING THE SHIELINGS IN THE GLENS.

# ANCIENT SEA-MARGINS.

## GENERAL DESCRIPTIONS AND FACTS.

1. Taking observed facts for our data, we know that there was a time subsequent to the completion of the rock formations, when this island (not to speak of other parts of the earth) was submerged to the height of at least 1700 feet. The proofs lie plain and palpable before our eyes, in the soft detrital masses, mixed in many places with marine shells, which overlie the hardened formations, reaching in some places to that height above the present sea-level.* As

* In his address as president of the Geological Society in 1842, Mr (now Sir R. I.) Murchison adverted to "the existence upon Moel Tryfane and the adjacent Welsh mountains, of sea-shells of existing species at heights of 1500 and 1700 feet above the sea, where they are associated with mixed detritus of rocks transported from afar, all of which have travelled from the north, the hard chalks and flints of the North of Ireland being in-

these are facts which have been amply observed and chronicled by others, I seek not to dwell upon them, but at once proceed to remark that the most ancient of the soft superficial formations appears to be that bed of blue clay mixed with boulders which occurs in so many places, particularly in Scotland, and which passes under the various names of ancient alluvium, diluvium, and drift, as also the local one of *till*. Its superior antiquity is proved by its being almost always found with nothing resting between it and the naked rock configuration of the district. The uniformity of its constitution, the far-transported rock-fragments included in it, its containing hardly any organic remains, and its apparent connexion with the polishings, groovings, and scratches, often found on the subjacent rock-faces, have drawn much attention to it, and given rise to some curious, though perhaps unstable speculations. It has been thought to indicate a period of unusually low temperature, when ice exercised a greater influence in modifying the earth's surface than it now does. The diluvium is found in Edinburghshire at 800 feet, and even somewhat greater elevations, above the level of the sea.

2. The more modern superficial formations consist chiefly of gravel, sand, and common silt, and are

cluded." See on this subject a letter of Joshua Trimmer, Esq., *Geological Society's Proceedings*, June 1831.

"—— Detrital matter has been spread over the greater part of Scotland to a height of at least 1500 feet."—D. Milne on the Parallel Roads of Lochaber; *Transactions of the Royal Society of Edinburgh*, 1847.

widely spread over the lower regions of the island. The two former are, however, found in some places at a very great height; in Argyllshire at about 1200, and in Wales at 1500 feet. In every valley in Scotland there are great tracts of gravel, mixed with sand, forcing upon the attention of the most unobservant traveller the fact of the former submersion of the land under the sea. Shells have been discovered in abundance in these deposits, at various heights under 360 feet,* and in Wales at the elevation above stated;† nearly all of them being common shells of the present sea, and thus making it clear that no great change in that department of the animal world has taken place since the sea was at the greater of these heights above its present level.

3. The fact of the submersion to that extent being admitted, several interesting questions arise. Has the change of the relative level of land and sea been accomplished by an upward movement of the land, or by the recession of the sea? Has the shift been slow and equable with regard to time, or by fits and starts with long pauses between, or by a slow movement interrupted by pauses? Has the time embraced by the whole series of phenomena been long or short, geologically speaking? What have been

* Mytilus edulis (*muscle*), Littorina littoralis, and other recent sea-shells, were found at an elevation of 360, 100, 80, and 40 feet above the present level of the sea, by Mr J. Craig, in the West of Scotland.—*Brit. Assoc. Rep.* 1840.

† See foot-note, § 1.

the general and particular circumstances and results of the whole movement?

4. Geologists have long recognised objects in physical geography to which they give the name of *raised* or *ancient beaches*, seldom at elevations over 43 feet above the present sea; and these, of course, imply an assumption that there have been corresponding pauses in the movement by which the shift of relative level was accomplished. The descriptions of these objects, however, are rarely minute, except with regard to the constituent materials, and the shells which have been found in them; scarcely any exact measurements of their elevations have been made; and hardly a suspicion has been any where intimated of their bearing relations to each other. Geologists have also, for some years, recognised, in the celebrated "parallel roads" of Glenroy, the memorials of the former presence of water at levels much higher than the above; but whether this water was the sea or an inland lake, is to this day a matter of controversy. Such is, in outline, the state of existing knowledge on what I may for brevity call the subject of the Emergence; very fragmentary and unsatisfactory, in comparison with the prominence of the subject as a chapter in the earth's history—the chapter which may in some respects be considered as the most interesting of all, since it connects the cold and remote eras of a different zoology with the occupation of the earth by man and the present races of

animals. It has been my task to examine the heretofore known examples of ancient sea-margins, with a view to ascertain if they bore any relations to each other; to follow out a chain of research amongst similar, though less obvious markings at higher levels; and to ascertain if these also stood in any mutual relationship: the final object being to determine as far as possible the questions above cited regarding the mode and circumstances of the shift of relative level. The general result is, that *the superficial formations bear the marks of former levels of the sea at various intervals up to at least* 1200 *feet,* thus involving the Glenroy terraces; and that the markings in the several districts examined, as well as in the neighbouring coasts of France and Ireland, do all of them fall into such a conformity as to prove that *the shift of level has been effected, from at least that height, with perfect equability throughout.* This conformity in the levels over so large an area is, of course, favourable to the idea of a recession of the sea, as opposed to that of an elevation of the land; since it is precisely what would result from the former operation, while there is an obvious difficulty in supposing that so large a portion of the crust of the earth could be subjected to repeated upheavals, and yet so preserve from first to last the original relation of the levels of its various parts to the centre of the earth, that between Paris and Inverness not a vertical foot of derangement could be detected. On

this question, however, I shall take no dogmatic course, speaking neither of upheaval of the land nor recession of the sea, but only of a shift in their relative level; and thus leaving it to others to settle the point, when my own facts have been received and further observations made.

### LOW COAST-LANDS, CARSES, ETC.—THE LOWER ANCIENT SEA-MARGINS UNIFORM IN HEIGHT THROUGHOUT THE ISLAND.

5. The most familiar phenomenon connected with this subject is the existence of stripes, as well as broad expanses of low land, bordering on the sea; in many districts, of a very equable surface; sometimes of sandy, sometimes of clayey composition; occasionally presenting beds of shells: comprehending, in short, the great bulk of those flat tracts which have been—usually on account of the latter feature—recognised as ancient beaches; comprehending, also, the well-known *carses* of Scotland, as well as those still lower sandy tracts near the sea, called in our country *links*, and in England *downs*. The class of lands so described may be said to form an irregular fragmentary belting round the island, strikingly distinct from the higher grounds which rise inland—generally of great agricultural value, and remarkable as forming the sites of many of the

principal towns of the empire, or of large portions of them. As they almost every where tell a plain tale as to their former submergence by the sea, the idea may the more naturally occur, that, were they by any accident re-immersed, a very important deduction would be made from the geographical area, and still more from the productive resources, of our island.

6. As striking examples of this class of lands, I may point to the sea-side plain stretching for several miles on both sides of Chichester; to the similar plain extending along the south shore of the Bristol Channel, between Weston-super-Mare and Bridgewater; and to the broad expanses of low land in Lincolnshire and other parts of eastern England. The carses along the Forth and Tay—vast alluvial plains,—the low gravelly lands of Moray, and the alluvial grounds skirting the Clyde near Glasgow, are examples of equally signal character in the northern part of the island.

7. It may, I believe, be safely said, that a sea 44 feet above the present would cover the whole of the districts referred to, excepting, perhaps, a few patches. The base of the comparatively steep ground rising from the interior line of these plains and stripes, even when they reach the highest grade of height, is usually at about that elevation, or a little lower, above the sea. An immersion, therefore, to this extent would leave us with new coasts, not only

much circumscribed, but considerably different from the present—for one thing, much bolder. It would also deprive us of the sites of the lower parts of London, Bristol, Liverpool, Newcastle, Glasgow, Aberdeen, and Inverness, and of the entire sites of Portsmouth, Southampton and Chichester, of Hull, Dumfries, Greenock, Leith, and Perth. The same submersion, extended to the Continent, would blot no small space from the map of Europe.

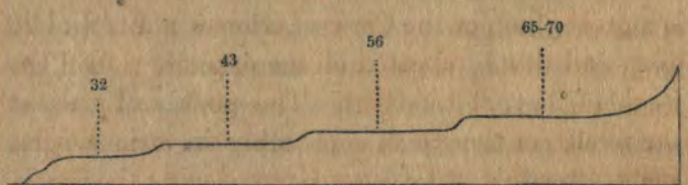
8. Where we have large expanses of these low lands, the flatness is usually very striking. For instance, in an extensive plain beside the Bristol Channel, the equability is so great over large areas, that the Exeter Railway passes over it for twenty-eight miles (from Ashton Water to Claverham Court) with a gradual rise of only four feet; and even this is perhaps to be attributed to the lines taking an oblique course athwart the plain, and against its seaward declination. Such equability makes the land almost the rival of the sea in the trueness of its surface to the centre of the earth, and forcibly suggests that water was concerned in giving it such a configuration. Such a plain is, indeed, precisely what would be presented to us as a piece of new land, if some of our shallow seas, such as the Bristol Channel, the mouth of the Humber, or the Solway Firth, were to sink forty feet below their present level. The carses in Scotland are also generally level, though not without partial inequalities, which a slight examina-

tion suffices to detect. In the configuration of the ground, thus level, with in many places the small inclination proper to a beach over which the tide rises and falls; in the cliffs which are often seen rising along the interior limit of the plain; in the constitution of the soil, composed of layers of sand or of clay, or of both, alternating often with beds of shells, we see clear evidence that these grounds were formed along the margins of an ancient sea; the highest inland part speaking of one about 44 feet above the present. Such is the announcement from these great expanses. When we look, however, to narrower examples of the great belting, such as are presented on bolder coasts, we find precise demonstrations, not only of an ancient sea-level about 44 feet above the present, but of several others intermediate between that and the present, particularly at 32, 27, 20, 11, and 8 feet—such appearing in the well-defined form of terraces or benches of land, the unavoidable result of the wearing power of the sea when it abuts against land of suitable slope and consistence. And, as already almost implied, these memorials of ancient sea-levels conform with each other in various parts of the island.

9. The best way to prove this will be to make a selection of places where this series of terraces is most perfectly exhibited. Let me first remark, that in the measurements stated throughout this book, I have in all cases endeavoured to keep as

near as possible to the height of ordinary spring-tides as a starting-point, except where the tides are of a decidedly abnormal character. I am well aware that the mean sea-level is the one which comes nearest to uniformity; but as the highest surface of former seas is the leading idea of the book, it seemed proper that I should rather take a point of tide representing the average utmost elevation of the present sea, even at the risk of encountering small discrepancies between different parts of the coast.

10. On the south shore of Loch Linnhe, in Inverness-shire, a little river, called the Rie, enters the sea (§ 98). The open space at the mouth of Glen Rie, about half a mile wide, is filled with gravelly flats presenting peat bogs and corn patches. Amongst the confusion of objects, it is easy to trace a succession of terraces falling back from the sea-shore,—




TERRACES AT GLEN RIE.

first, one about 32 feet, then one at 43. It is of no consequence at the present moment, but will be so by-and-by, that these are followed by others at 56,

and from 65 to 70. In the neighbouring inlet of Loch Leven, the strait forming the ferry at Ballachulish (§ 97) is produced by the starting out, from the base of the steep hills on both sides, of two flat gravelly plains, partially resting on subjacent rock. These are solitary examples of ancient beaches, and they are from 42 to 44 feet above the sea.

11. Mr Prestwich has described * an ancient beach on the coast of Banffshire, from 6 to 12 feet above the sea—that is, at 12 as an extreme.

12. Passing to another portion of the island, a terrace, at about 11 feet, is well marked at St Andrews links (§ 66); near Stirling, where it constitutes the beautiful *Crooks* of the Forth (§ 120); at Musselburgh, the site of which, with its links, is formed by it. On the banks of the Tay, at Kinfauns, there is first a border of alluvium at 8 feet, and then the carse at 32; this is repeated at Perth, where the lower plain constitutes the celebrated *Inches*. There is a great reach of the Carse of Gowrie at Errol at 20 feet; and this is repeated on the opposite side of the Firth of Tay, at Lindores. The plain at Reres, at the mouth of the Eden, is precisely the same height. Look, after this, at Glasgow Green, beside the Clyde, on the opposite side of the island: there, a first haugh at 11 feet is immediately overlooked by one which, at the fore-edge, is about 26 feet, but rises a

* Proceedings of the Geological Society, May 1837.

little inland. Between Greenock and Gourock, on the Firth of Clyde, is a low stripe at 12 feet. A 32-feet alluvium appears at Dumbarton, and along the banks of the Leven. In the island of Bute, a low beach (not above 8 feet) extends along the coast between Rothsay and Ascog; a fine example of that at 32 feet appears in the valley behind Rothsay, forming the site of several large factories. On the Tweed, again, a little above Berwick, appears a 32-feet haugh; further up, at Gainslaw, one at 44 feet.*

13. Captain Vetch has described † a series of six or seven shingly terraces in the island of Jura, extending back from the present shore to a distance of half a mile, and a height of about 40 feet. It is unfortunate that the heights of each are not given. Mr Alan Stevenson, however, describes ‡ two ancient beaches at Ross, in the isle of Mull, one rising directly above the other, composed of gravel and small boulders, and covered over with a thin but tough coat of mossy grass; the heights being 25 feet 3 inches and 40 feet 5 inches above *the highest tide-line that could be seen*—elevations which come very near to two of those here stated as prevalent, when an

* These Tweed haughs are from Mr Milne's paper on Glenroy. The Dumbarton and Leven alluvia are from MS. communicated by the same gentleman.

† Transactions of the Geological Society, 2d series, i. 416.

‡ Jameson's Journal, April 1840.

allowance is made for the probable greater height of Mr Stevenson's datum.

14. A terrace, long recognised by local geologists as of this character, extends irregularly along both sides of the Firth of Forth, in some places 20, in others 26 feet. It is noted for the shells found in it. It appears conspicuously between Newhaven and Granton, where it is 20 feet (§ 119). In a narrow stripe on the opposite shore, but at 26 feet, it forms the site of the principal part of the town of Kirkaldy. At Portobello it expands into a sandy plain, the upper extreme of which is 26 feet. In reality, the several points here referred to express two distinct terraces, each commemorating a pause of the sea. The stripe of ground on which the principal parts of Dundee are built, extending between the Firth of Tay and the base of the neighbouring heights, is precisely a repetition of the 20-feet terrace.

15. My examples from the south are not numerous, in consequence of limited opportunities. I may, however, cite a specimen of the 32-feet terrace, extending along the south bank of the Esk at Longtown, having Netherby Castle seated upon it; an example of the 11-feet alluvium on the Ribble, at Preston; and the great Chichester plain already alluded to, which rises at its inner extremity to 42 feet. The low lands beside the Thames, including the site of some of the lower parts of London, Southwark,

and Lambeth, are examples of this group of objects. Their general form, in connexion with the higher grounds backing them, is precisely what we see beside the rivers and firths of Scotland, and a community of cause becomes indubitable. This point will be returned to. I am sorry to be able to present but few measurements from the banks of the Thames. I can speak, however, with confidence of the plain on which Deptford stands. It is perfectly equable, like that at Portobello on the Forth, and rises at its inland extremity to about 30 feet.

16. The nearness of all these examples—and they could be multiplied beyond the patience of the reader—to one set of elevations—namely, 8, 11, 20, 26 or 27, 32, and 43 or 44 feet—must be regarded as tolerable proof that these are points above the present sea-surface, at or about which pauses were made in the shift of relative level, for at least a large part, if not the whole of the island. We shall, by-and-by, see additional proof, leaving the fact of uniformity for the whole island beyond dispute.

17. A question will naturally arise—why does one of the terraces appear at one place, and another at another? The answer is, that in the first place, such markings of the land by the sea are matter of accident, depending on the configuration and constitution of the ground originally presented to the action of the sea, or the accommodation which the ground gave for

detrital depositions; in the second place, the subsequent preservation of such memorials is equally matter of accident, because every such object has been exposed to destruction from the very agent which formed it, when that agent fell to lower levels, and there pursued its ordinary work of undermining and carrying away whatever soft matters might be exposed to its action. Thus, while at the 20-feet level, it would in some places carry away all memorials of the 26-feet and higher levels—in other places, spare a few fragments. We know that the carses were formed under the 44-feet sea (so to call it), for no part of them, however far inland, rises above that height. In their seaward districts, however, they sink to 32, 26, and even 20 feet, the lower connecting with the higher portions by intermediate slopes; while sometimes a fragment of the higher levels remains isolated within the lower portions, usually made the more distinct by its different constitution, (perhaps presenting gravel or sand, while they present clay.) I conceive that, in many such cases, there has been a cutting out of the original surface by the sea working at a lower level. We see several of the lower ancient beaches actually undergoing the process of demolition at the present time. For example, some considerable masses of the 26-feet terrace have been swept away from under the bold coast between Kirkaldy and Dysart within the recollection of people still living.

## OSCILLATIONS IN THE SHIFT OF RELATIVE LEVEL OF SEA AND LAND.

18. Submarine forests have familiarised geologists with the idea of oscillations in the shifts of relative level; that is, replacements of the sea at points which it formerly left dry. We have, in the group of objects now under our attention, some additional proof of an interesting kind, that the sea has occasionally, in the more recent ages of the process, resumed parts of its formerly deserted domain. In the Carse of Gowrie, at Polgavie, where it is about 20 feet above the adjacent firth, there is first nearly that depth of various clays; then a 4-feet bed of peat extending under the sea, containing remains of alders and birches, upright as they had grown in the pure blue clay still further down. At three several points in the superincumbent clays—namely, at $16\frac{1}{4}$, $11\frac{1}{4}$, and $7\frac{3}{4}$ feet from the surface—there are vegetable roots cut off by a layer of marine shells,* forming, in all, proofs of four recurrences of the sea; the first time, after the land had been a very long period exposed, for 4 feet of peat must require no brief space to accumulate. In the parish of Errol, a few miles further up the Carse, a bed of peat is found from 20 to 30 feet below the surface.† On the

* Beauties of Scotland, iv. 227.

† New Statistical Account of Scotland, x. 377.

opposite side, in the parish of Newburgh, at a spot estimated as 40 feet above the sea, there is, below a 5-feet bed of rich alluvial clay, a 2-feet one of peat, presenting branches of *Alnus glutinosa* and *Coryllus avellana.** This shows an oscillation when the sea was not less than 35 feet above its present level.

19. To the same purport are certain observations which have been made in the low grounds near the Lake of Spynie in Morayshire. In a plain, recently marshy, the first of a series rising above the lake, and only a few feet above the sea, there is a drain, the sides of which exhibit, in about the space of a foot, curious alternations. First, there is a marine shell deposit; then marl with remains of fresh-water shells; then a bed of peat; finally, marine shells again (oyster, cockle, &c.) †. The fresh-water marl is, of course, satisfactory proof that the sea had temporarily withdrawn in the interval between the deposition of the subjacent and suprajacent matters.

20. Nor have such oscillations been confined to these low, or comparatively low levels. At a spot near Trinity, from 70 to 80 feet above the waters of the Firth of Forth, there is a 1-foot bed of peat under a 10-feet one of sea-sand, the peat containing roots of trees which evidently had grown in the underlying

* New Statistical Account of Scotland, article *Newburgh*, the production of the Rev. Dr John Anderson, author of a prize essay on the Geology of Fife.

† See also Duff's Sketch of the Geology of Moray, p. 10.

blue clay, besides "stems of reeds and other marsh plants, and numbers of small seeds of some shrub, not unlike those of a species of whin." * At Galashiels, the base of Buckholm Hill was lately cut down for the Hawick railway, when the following series of objects was presented: first, the rock of the district, then a bed of diluvium, next a thicker bed of debris from the hill side; above this, stratified sand and gravel, and finally, debris from the hill again, covered with the vegetable mould. The interjection of dry hill debris between the two watery formations could only, I apprehend, be accounted for, by supposing an interval of exposure to the air between the submersion during which the diluvium was produced, and a second which was attended by the deposition of the stratified sand and gravel. The spot is 350 feet above the sea.

### THE LAST SHIFTS, PERHAPS, WITHIN THE HUMAN PERIOD.

21. There is some evidence, certainly not satisfactory, but yet claiming to be not wholly overlooked, leading to the conclusion that the last movements of emersion have taken place since the island became a seat of human population.

22. The few remnants of a higher plateau throughout the Carse of Gowrie almost all bear names in

* Milne on the Parallel Roads of Lochaber, p. 50.

which the Celtic word for island forms a part: thus, Inchyra, Megginch, Inchmichael, Inchmartin, Inchsture, &c., as if a primitive people had originally recognised these as islands in the midst of a shallow firth. Perhaps there is little consequence to be attached to this fact, since the extreme wetness which even in recent times pertained to the low lands of the Carse, may have appeared a sufficient reason for so distinguishing any snatch of more elevated and firmer ground. The minister of Errol reports, unfortunately not in a direct way, the finding of the remains of a small anchor, about fifty years ago, in a piece of low ground on the estate of Megginch.* In the same district, which is fully a mile from the margin of the firth, a boat-hook was discovered 18 feet below the surface, "sticking among the gravel, as if left by the tide on the sea-shore." †. This relic has been preserved by the farmer who found it. I am also assured that what were considered as the remains of an anchor were found some years ago in casting a drain below Flaw Craig, a cliff which overlooks the Carse between Kinnaird and Fingask. Time out of mind, it has been a popular belief in this district, that Flaw Craig rock bore "the remains of a ring to which ships were fastened when the sea ran at the

* New Statistical Account of Scotland, article *Errol.*

† Here, and for what follows, I quote a letter from a lady, the daughter of one of the chief proprietors in the Carse.

bottom of the hill." A man living a few years ago alleged that he had seen the iron in his youth, as he climbed along the face of the crag in bird-nesting. So also it is told that the rock on which Castle Huntly stands, in the centre of the Carse, once had rings fixed to it, for mooring the boats formerly used in sailing over the surrounding waters. A circumstance in the title-deeds of at least one estate on the slopes descending to the Carse, has given some force to these popular beliefs in the minds of the educated classes, namely, that they include a right of salmon-fishing, though the lands are separated from the firth by the whole breadth of the Carse.

23. These particulars would, perhaps, not be deserving of notice, if they were not in conformity with some others that are better authenticated.*

* The sea is embanked out from an inlet called Traeth Mawr, in Carnarvonshire. There is a series of embankments higher up, which were made in the sixteenth century. "It is evident that these embankments are not the sole or principal cause of the sea no longer flowing within them, but that the natural recession of the sea (or elevation of the land) induced the inhabitants to anticipate, by the erection of earthen mounds, that which would have been produced in a few years by other causes. The sea-mark may be traced on the surface of the escarpments in several of the islands in the Tremadoc valley, many feet above the present level of high-water. Tradition also lends its aid. From the rocky ground of Inshir, Madoc, one of the princes of North Wales, leaving his native country, *sailed* to unknown lands. And to descend to more recent times; I was informed that the parish register of Penmorfa contains entries showing that a place in the parish called *Y wern* was once a sea-port, which, immediately before the erection of the great embankment, was several feet above high water."—J. E. Davis on Geology of Tremadoc, Carnarvonshire, *Quarterly Journal of Geological Society*, May 1846.

Mr Smith of Jordanhill has adduced some curious proofs to show that

In 1819, in digging the carse land at Airthrey near Stirling, where the surface is nearly 25 feet above high-water of spring-tides in the river, which flows at a mile's distance, there were found the bones of a large whale.* No doubt can be entertained that this animal had perished here at a time when the sea stood at some unknown point upwards of 25 feet above its present level. About five years afterwards, the bones of another large whale were found on the estate of Blair-Drummond, seven miles further up the carse, and probably at a greater elevation above the sea.† In this case, a deep moss had covered the ground, indicating one long section of the interval of time since the death and deposition of the animal. The clay was here only four feet deep, and beneath it was *another moss*, the memorial, of course, of an inter-space, during which dry land had existed at this spot. The bones rested on the lower moss, but did not penetrate into it. We may suppose, therefore, that it was immediately after the sea recurred here, that the whale was brought to the spot. 'But the most valuable fact in connexion

the sea now stands at a higher relative level on the coasts of Normandy, Brittany, and the Channel Islands, than it did in the eighth century.—*Quarterly Journal of Geological Society*, August 1847.

* Edinburgh Magazine, August 1819. The bones "were found at a depth of from 18 inches to 3 feet from the surface, in what is termed recent alluvial earth, formed by the river Forth, and composed of a blue coloured sludge or sleek, with a covering of peat earth a few inches thick."

† H. Home Drummond in *Wernerian Transactions*, v. 440.

with these relics is, that in each case there was found among the bones a fragment of stag's-horn, containing a perforation of an inch in diameter, evidently artificial, and, in the Blair-Drummond instance, containing the remains of rotten wood. It was the opinion of Mr Home Drummond, on whose property the latter whale was found, that this horn had been the handle of a rude instrument, perhaps a harpoon, and that it had been used in some way in connexion with the animal when it was stranded.* The purport of these facts and inferences evidently is, that a human population existed in the land before some of the last shifts of the sea-level. I am, moreover, told that a human skull was found deeply imbedded in the carse clay at Grangemouth, when digging for the formation of a dock, at a place where recently a garden had flourished. The question must be left, however, to be determined by further evidence.

### A SECOND GROUP OF ANCIENT BEACHES AT UNIFORM LEVELS.

24. We have seen that the group of low flat lands and terraces just described is backed by rising grounds comparatively steep, which would be left as

* D. Milne on the Parallel Roads of Lochaber. Edin. 4to, p. 53.

a new and somewhat bold line of coast if a submergence to the extent of 44 feet were to take place. Above this point geologists have hardly ever as yet looked for ancient sea-margins; but it is, nevertheless, a fact, that a second set of flattenings is presented very conspicuously; the first at 53-6 feet, the second most generally and distinctly at 64-70, but sometimes running up to 85 or 90 feet, as if, in these cases, two distinct terraces had been resolved into one: finally one at from 96 to 117 feet; above which there generally commences a new set of comparatively steep slopes. These are as characteristic features of the general outline of this island as the other, and, though less apt to appear as something relative to the workings of the sea, are nevertheless so prevalent, that I am at a loss to understand why some general cause has not been speculated upon as concerned in their formation.

25. I will recall a few objects in the physical geography of the country with which many persons are likely to be familiar. First, the form of ground on which the higher parts of London are built—a fine equable slope extending from about 70 feet at the end of the Crescent in Regent Street, up to about 90 feet at the Regent's Park. It is exactly such a slope as a tide would form in its periodical ebb and flow. That might be accidental—but then the object does not stand alone. Behind Deptford is a bench of ground of precisely the same form, and

similar elevation. On the south side of the Mersey at Seacombe, opposite to Liverpool, from a steep sea-fronting cliff of 70 feet, there extends up to near 90 feet at Egremont Church, a plain exactly like the two above mentioned. Look, again, at the country bordering on the Firth of Forth: here, behind Granton, at Easter Duddingston, and through a considerable part of Haddingtonshire, there is seen precisely the same kind of plain, overhanging at the same height a low stripe equivalent to that at Deptford. Or examine the banks of the Clyde at Glasgow: there, both in the western suburbs at the Sauchiehall Road, and in the eastern suburbs near the House of Refuge, we have a complete repetition of this form and height of ground. Next, at St Andrews, there is a similar plateau, on the front of which the ancient city is built. The banks of the Dee at Chester are another example. Such uniformities in configuration and height are surely very remarkable. A plateau beginning between 90 and 100, and often found at 108 and 112, but occasionally entire and distinct up to 117, is not less observable. We have it behind Inverness; on the right bank of the Tay near Perth; basing the high grounds on which Edinburgh is built; extending along the Tweed as far as Kelso, which is seated on it; and in various other places.

26. These are broad palpable features of our country, which no one who has seen and studied the first

group of ancient beaches can doubt to be ancient beaches also, although apt to be more cut by water-courses, and rounded and worn by meteoric agencies, as well as less productive of shells. They connect themselves one with another unmistakeably, by their uniform height, and their common features of great breadth of slope, and their longitudinal extent in bordering our present shores; adding powerfully to the evidences already adduced for an equability in the shift of the relative level of sea and land, as concerns our island. I venture to affirm that a very large proportion of the plains near our coasts, keeping out of view the lower ones formerly spoken of, will be found of these limits as to elevation above the present sea. There is another, but much less broadly marked terrace, usually found at from 53 to 56 feet. A section drawn from Errol in Perthshire to Edinburgh would show it first at Errol Hill and at Newburgh, on the opposing sides of the Firth of Tay, and then at Seafield near Kirkaldy, and at Granton, on the opposing sides of the Firth of Forth. But I have not detected it in many other districts, and therefore regard it as far from co-ordinate with the three superior members of this group of terraces.

27. A certain dubiety or anomalousness may be remarked with regard to the terrace described as having an upward limit of about 90 feet. While on bold ground a marking is generally found at about

64, and from that to 70 feet, we often find this extending on grounds of the opposite character to 85 or 90. It has on several occasions appeared to me doubtful, whether there be one or two pauses of the sea indicated by these levels. One might suspect that two markings had been blended into one by a slow and equable movement in this part of the shift; or, perhaps, it may be to some extent explained by a reference to the different effects of the working of the sea on coasts of different characters. I have, at least, seen reason to suppose, that where the element has beat against steep ground, we have as a result a marking expressive of *low-water* only. Upon the whole, however, I am inclined to think that there has been a pause of the sea at about 70, and another at 90 feet.

28. A superiority in importance has been unhesitatingly assigned to the preceding examples, from considerations of the frequency of their occurrence, and the broadness and perseverance of the marking where they do occur. Judging from this island, there can be little room to doubt that the sea has paused longer at about 112, 90, 70, and 26 feet above the present level (taking medium or conspicuous heights, for brevity), than at 56, 44, 32, 20, or any inferior height. This is a consideration which materially reduces any difficulty that may have been felt to attach to the subject in consequence of the narrowness of the intervals; for, of course, the last

group being comparatively rare, and less strikingly marked, we are left in the more freedom to distinguish, and to bring into connexion and relation, those terraces which approve themselves more palpably to the eye.

### HIGHER BEACHES.

29. Notwithstanding that the general form of the country is apt to assume a bolder character above 112 feet, there is no difficulty in detecting a series of ancient sea-margins above that height, especially in valleys, where there was a plentiful material for such objects in the detritus of lateral streams, and where, moreover, the estuarial character of the ancient seas gave a tranquillity favourable for their preservation. The first of much importance is one having a range of vertical extent not much less remarkable than one of the last group, namely, from about 186 to 195 feet. It is strikingly developed in the form of a broad gravelly terrace, extending from the site of the Crescent at Bath across the Park, and so on by Weston to Partis College and Kelston House, a distance of about four miles; equally so in various parts of Edinburghshire, at St Andrews, and at Inverness. The next of equal notability is at about 277 or 280 feet, broadly marked on the hills around Bristol; not less so in Edinburghshire, and

at Inverness. The last I shall here mention as co-ordinate with these is at 392 feet, which is likewise found in a great variety of places. All of these are broad and prominent objects in the physical geography of the country. The identity of their constitution, configuration, and height, leads unavoidably to identity of cause; and, after studying the series of similar objects leading up to them, it is impossible to doubt that that cause is the sea.

30. Amongst them are intercalated various beaches of less note, but which nevertheless occur in many places. One is little above the last of the preceding series, generally found at about 125 or 126 feet, but having a range of at least from 122 to 128. Another is at 144 feet; this is presented in great extent at Greenwich. A third, more frequently found than either of the preceding, and also more broadly marked, is between 165 and 170 feet. Such, also, is the character of a fourth, at 202–13. Those occupying the higher intervals are less prominent. There are a few occurrences at 217–23 and 243; some more distinct and certain in their character, at 325, and 345 or 347. From this cause, the great markings of this range of vertical space enjoy a distinctness and conspicuousness which add not a little to their value as elements for the general conclusion.

31. Having thus introduced the subject, I shall proceed to describe the appearances which occur in

the special districts which I have had an opportunity of examining; reserving, as much as possible, any other general observations which may be called for, till the conclusion. The reader will here receive more minute descriptions of the objects already adverted to, where such appear necessary for the development of the subject; but I shall as far as possible avoid repetition.

## LOCAL RESEARCHES AND DESCRIPTIONS.

### THE VALE OF TAY.

32. The river Tay is well known to be, of all British rivers, that which pours the greatest quantity of water into the ocean.* With its large tributaries, the Earn, Isla, Tummel, Garry, &c., it drains about 3000 square miles of country,† a large proportion of which is hilly. The last twenty miles of its course is an estuary—the Firth of Tay—but the sea affects the river somewhat further up, namely, to a point a little above Perth.

33. The relics of ancient alluvia are abundant throughout this great valley.

34. The Firth of Tay lies between the quickly rising grounds of Fife on the south side, and the Carse of Gowrie on the north. The latter, as is well known, is an alluvial plain, ten or twelve miles in

* In the mean state of the river, 3640 cubic feet per second.—*New Statistical Account of Scotland*, x. 8.

† Strictly 2398, exclusive of the Earn.—*Ibid.*

length, by from four to six in breadth. So low and so uniform is it, that, looking from the opposite shore at Newport, we scarcely see anything intervening between the firth and the hills. About 20 feet above the sea in its central and eastern parts, it rises to 26 towards the west, and even a little more. It has been obvious, since before the days of geology, that the Carse is composed of the spoils of the Highlands —the finest detrital particles, which, by their lightness, were carried furthest down; and we must acknowledge the partial truth of a jocular remark made by the Duke of Athell at a public meeting fifty years ago, that, "if every man had his own, the proprietors of the Carse would have nothing but the barren sands upon the sea-shore, while the Grampians would be covered with a fertile soil, and the vegetation which it produces." *

35. The Carse, and certain grounds of similar character on the opposite side of the firth, present abundant evidence of vacillation in the relative level of sea and land (§ 18.) It also presents some proofs, in addition to those which tend to establish that some of the last shifts of relative level happened after the country had begun to be inhabited (§ 22.)

36. At Dundee, the Firth of Tay passes through a narrow channel between comparatively high grounds. On these are various markings of former

* Beauties of Scotland, iv. 226.

levels of the sea. A very well marked ancient beach, at about 56 feet, appears on the north side at Craigie; on the south, at about a mile east of Newport, and also at Wormit Bay. The principal streets in the centre of Dundee are upon the same alluvial elevation as the Carse. Both of these ancient beaches may be traced for miles along the coast of Forfarshire to the eastward. At Carnouctie, however, the upper one runs up to an elevation of fully 90 feet, without any very distinct bank-like interruption; an example of a curious eccentricity in these formations, which, as already hinted, may be traced to peculiarities in the original configuration of the ground, the gentleness of the declivity having apparently prevented the sea from making any indentation in the course of its descent from one stage to another. This broad terrace is of sandy surface. Between 40 and 50 feet above its inner line, another of great extent, but clayey material, begins.

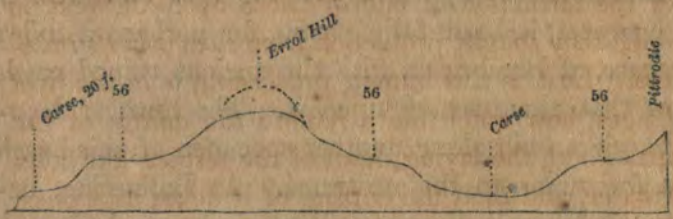
37. From the Carse level, the ground on which Dundee is built rises rapidly against the face of a hill called the Law, 570 feet high. On this ascent, an ancient sea-line, about 208 or 213 feet high, may be traced (a little way below the villa of Cleperton). Behind this is a flat outline of country, the terrace-like appearance of which strikes the eye at Newport, and which is about 389 feet above the sea.

38. From the abrupt rise of the ground on the Fife side of the Tay firth, there is little to favour

the formation of ancient beaches in that district. Still they are not wanting. The 56-feet terrace, mentioned as appearing to the east and west of Newport, is beautifully shown, for perhaps a mile's space, at Bambriech, with the ancient ruined castle of that name seated upon it. The town of Newburgh is built along another specimen of this beach a few miles to the westward. At Balmerino, between Wormit Bay and Bambriech, we have not this terrace, but one a little higher, extending from about 60 to upwards of 70 feet: on this fine platform the abbey of Balmerino is placed. Viewed from Dundee Law, the high country above Balmerino comes to a line as straight to appearance as the top of a wall, and perfectly level. It is 466 feet high, being the elevation of one of the ancient sea-margins. I have often found table-lands thus coincide with beach elevations, apparently denoting that they were produced by the erosive power of the sea.

39. It has been mentioned that the Carse of Gowrie contains a few exceptions from its prevalent level. The largest of these is the long low hill of Errol (rising in one part to about 140 feet), near the shore of the Firth, and almost opposite Newburgh. On both sides of this hill—both towards Newburgh and towards the hills skirting the Carse to the north—the 56-feet terrace is easily traceable: it makes a fourth appearance on the face of the

hills, near Pittrodie. Of course, when the Carse was submerged to this extent, the top of Errol Hill




SECTION OF CARSE OF GOWRIE, ACROSS ERROL HILL.

was an island, beyond all mistake. The same terrace appears in a somewhat less distinct form at a place called Toft Hill, near the upper extremity of the Carse.

40. All the little glens which open into the vale of the Tay in this quarter—that is to say, both those in Fife and those on the north side of the Carse—exhibit relics of ancient deltas, and these are marked pretty conspicuously in some instances with the traces of a succession of sea-levels. It is here, as in other cases, surprising to observe what huge masses of gravel each little stream has brought down in its young days, when its course was even briefer than now—always, too, deep intersections made in these detrital masses, forming the modern channel of the tiny rill. At the opening of the Glen of Rait—a difficult defile, once the main road between Dundee and Perth—there is a great, but worn and irregular, gravelly terrace of about 120 feet above the sea. A prominent cliff of

it, hanging in peninsulated fashion over the burn, has been taken advantage of by our early ancestors for the formation of one of those open-air forts in which they sought protection from each other's rudeness. Lost as this human proceeding is in the mist of ages, how much more remote the doings of the burn—both the laying down of the terrace-like delta in water, and then the cutting of it down as a piece of dry land into two parts!

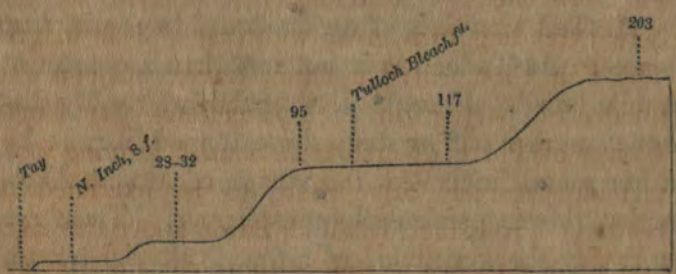
41. At the head of the Carse of Gowrie, the Tay is joined by its large tributary the Earn, on its right bank. For several miles up the vale of the Earn—all along by Ayton, Kilgraston, Bridge of Earn, and Dunbarny—the course of the stream is through a flat alluvial tract resembling the Carse, and which may be regarded as a continuation of it. Under a point between Kinmonth and Moncrieff, this alluvium is 29 feet above high-water in the river; towards the hills it rises to a little more. The uniform level of the road passing from Bridge of Earn to the Bein Inn across this flat must be in the remembrance of many.

42. In the narrow part of the Tay valley, between Kinnoull and Elcho, there is little room for ancient alluvia. The eye of the traveller on the Dundee road is, nevertheless, arrested by an extremely well defined low line of bank along the opposite side of the river, being a portion of that alluvium below the Carse which was formerly alluded to: it is here about 8 feet above the tide. There is also, under

the western extremity of the craggy face of Kinnoull Hill, and just without the Kinfauns pleasure grounds, a small but well defined fragment of a terrace 128 feet above the river.

43. Pass into that fine open expanse of the valley in which Perth is situated. There the course of the river is from the north to the south, Perth being on the west side. On the east, the hills are too near and abrupt to allow of many memorials of ancient sea-margins; but on the west, the expanse is filled with alluvia of various dates in the most striking gradation. First, at about 8 feet above the river, we have the low alluvium just alluded to, but here extending to a great width as well as length. The Fair City, seated upon it, leaves an open and uncovered portion in each direction—the famed INCHES of Perth (North and South) forming promenades scarcely any where to be exceeded in beauty. From their small elevation above the river and sea, the Inches, as well as those parts of the city on the same level, are occasionally inundated. Behind this great meadow is another, equally flat, and equally extensive, but upon a different level: a line of *brae* or cliff divides them as one step of a stair is divided from another. The upper meadow is, at its front parts, about 28 feet above the tide-level, but rises a few feet more towards its inland border. Now this upper meadow is simply a continuation of *the Carse.*

44. Standing on the North Inch, we see the cliff of this upper alluvium sweeping along like a boundary wall. It can readily be traced within the town, being the cause of a steep of small extent in several of the streets. If we now take a stand upon the upper alluvium, we shall see a similar cliff, but of greater height, rising behind it in the same fashion, here and there advancing into promontories, and again receding into bays, for a considerable way to the north. Above this cliff is a third plain, smooth and entire over all the above-mentioned promontories,—between these, scooped out into hollows.




TERRACES NEAR PERTH.

This third plain is of different composition; for, while Nos. 1 and 2 are almost purely of clay, No. 3 contains much gravel.

45. The third terrace is first to be traced on the face of the hills a mile or two south from Perth. Behind the city, we find the Glasgow road ascending its cliff. It is converted to good economic ser-

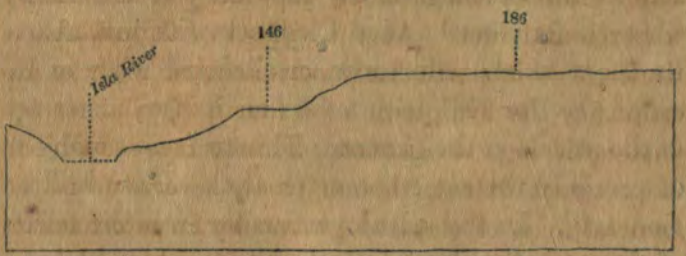
vice at Tulloch bleachfield. Then comes the opening of the valley of the Almond, which breaks its continuity. Beyond that point it is resumed, and goes on to a point near Luncarty, where the two rivulets, the Shochie and Ordie, just before they pour almost contiguously into the Tay, cut it down, leaving one fragment, with a perfectly flat top of a few acres, between them, popularly called the Dune Hill, a name which argues its having been taken advantage of for a fort in early times.* As nearly as I can calculate, this terrace is generally at its front above 95 feet above the sea, rising thence to about 117 in its inland parts.

46. This terrace is of various breadths at different places. At Tulloch it is not less than a quarter of a mile broad. Here, looking inland, we readily discover another cliff or steep slope, topped likewise by a horizontal line. At the village of Mount Alexander, this is particularly conspicuous. These are in reality the symptoms of a fourth alluvial terrace distinguishing this district. This terrace is found to be of great extent, though partly severed from the general mass of elevated ground by an intermediate valley: its elevation is about 203 feet above the sea.

* The Dune Hill forms for some space the line of the Scottish Midland Railway, which has thus to bridge both the Shochie and Ordie. The top of this hill is reported to me by a gentleman connected with the railway, as 96.91 feet above high-water at Perth. This I have ascertained by the level to be a little lower than other parts of the terrace.

47. At Luncarty, and on the opposite side of the river, at Jeanyfield, there are specimens of a lower terrace, perfectly coincident in elevation (85 feet above the sea?) At 32 feet below the Jeanyfield flat, is another, which a quarry enables us to ascertain as entirely composed of gravel or shingle, containing no fragments larger than a cocoa-nut.

48. We now pass up the river Tay to where the Isla joins it on the left bank, in the midst of a country marked only by gentle declivities. This meeting of waters is 93 feet above the sea.* On the slopes bordering the Isla, it is easy to trace a terrace at 146 feet above that level. One of them comes to a table-land at 186 feet; and on this the village of Mickleour is situated. Similar flat land borders the right bank of the Tay, sweeping down at its




MICKLEOUR.

bluff edge towards the water-side, like the fall of a curtain.

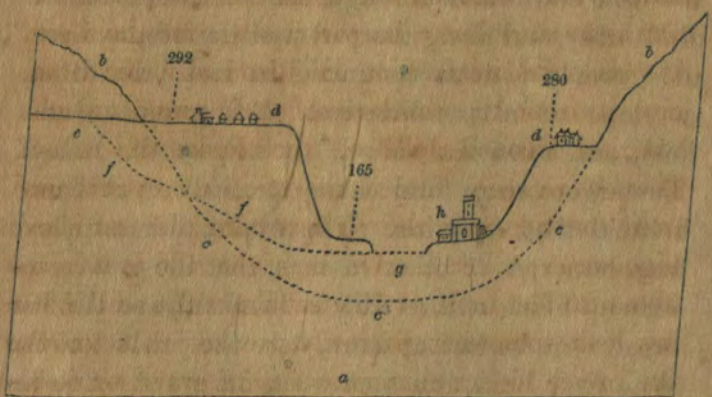
* Stobie's Map of Perthshire.

49. We must now shift the scene to another portion of this valley.

50. At Dunkeld, as must be well remembered by many of my readers, the mountains approach so near as to allow but a narrow passage for the river. At this point, its dashing Highland ally, the Bran, joins it from the south-west. All round are the beautiful wooded hills of the Duke of Atholl. Though scarcely fifteen miles of direct distance from the tide-way, the river is here 145 feet above high-water at Perth. On its right side is a *haugh* about 20 feet high, or 165 feet above the sea. When we look somewhat narrowly, we see that another and much higher alluvium of pure gravel skirts the river at this place. It appears abutting against the rocky hills above Dunkeld, equally so at Birnam; also in the opening of the sub-valley of the Bran, where a farmstead called Claypotts sits just above its inner skirt. Moreover, an isolated mass of it, called the Tor Hill, with a villa on its top, starts up in the middle of the glen near Birnam Inn—an object of precisely the same character as the Dune Hill of Luncarty. In the sylvan profundity rises the tower of the ancient ruined cathedral, but not so high as to top these gravelly terraces. They are in fact from 134 to 147 feet above the river. It becomes perfectly evident to the onlooker, that these terraces are the remains of a gravelly flat which once formed the bed of the valley from side to side. The present

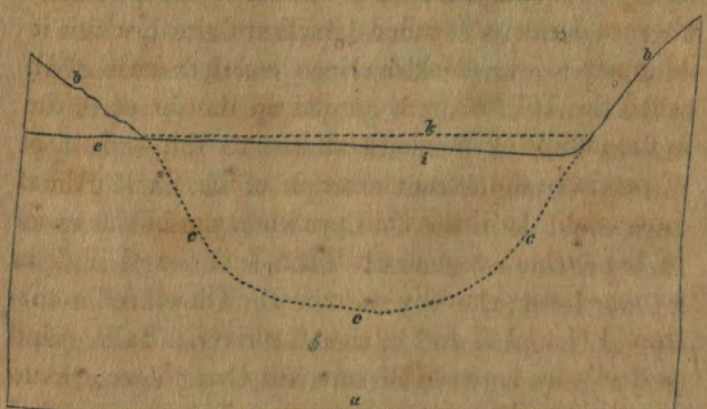
valley shows merely a huge trench cut through it for the passage of the river. We look into the expanse

SECTION OF VALLEY AT DUNKELD.




*a*, present sea-level. *b*, hills forming the valley. *c*, their ideal continuation. *d d*, the terraces. *e*, *f*, *f*, course of the Bran. *g*, the Tay. *h*, Dunkeld.

SAME VALLEY IN A SUPPOSED PRIOR STATE.




*a b c*, as above. *e*, embouchure of the Bran. *i*, unbroken gravel formation. *k*, surface of the sea.

of the vale which opens a mile further up, and see a wide low plain permeated by the stream, without any but a slight fringing of terraces on the hill-side. We look downwards through the pleasure-grounds of Murthly, and along the parish of Caputh, and see the gravelly plateau continued in vast breadth of development in that direction. It is great at Dunkeld, and *down* the valley, but not *up* the valley. This argues some local cause, terminating at Dunkeld in that direction. The explanation supplied from hundreds of other cases is, that the great gravelly up-filling of the valley at Dunkeld, and the fine broad terraces farther down, were the product of the little river Bran, at a time when the sea stood somewhat more than 280 feet above its present height, and sent an estuary up to Fascally. Pouring down amongst its rough alpine solitudes, it brought with it large quantities of stones, small and great, which it rounded by mutual collision into gravel, and with this, in the course of time, it gorged up the throat of the ancient firth at Dunkeld almost to the surface of the sea—a magnificent example of what a Highland burn could do in the old days when the hills bore all their pristine roughness! The sea at length sank to a lower level; the Tay and the Bran itself fell a-cutting at the mass, and in time hollowed out the grand profundities between Birnam and Craig Vean. And so, there, in the space thus vacated, do we now find the Bran tumbling down cascades which tourists go

to see reflected in Ossian's Hall, and the Tay pressing on in its milder and more majestic course, beside the ruined fane in which the Wolf of Badenoch found a grave and Gavin Douglas exercised episcopal functions: a scene of beauty all the more singular when we reflect on this, the last chapter of its geological history! *

51. I shall now turn back for a moment to pursue this terrace to its termination on the east side of the river. Passing along the road from Dunkeld to Mickleour, we are upon the top of the elevated plain. It perseveres for a few miles. The parish-church of Caputh is situated upon it. At last, when we approach Delvine, we find it suddenly stoop down into the great low plain of the Stormont, the intermediate curtain-like cliff being about 60 feet of vertical height. Here a striking and beautiful proof occurs, that the sea rolling on the lower plain formed the limit which this cliff gives to the higher one, by eating away a portion of the materials and strewing them down at a lower level. A few hundred yards out from the face of the terrace, is the extremity of a

* Attention was drawn to the Dunkeld terraces by Mr Charles Maclaren (*Scotsman, 9th August* 1843), without any reference being made to the source of the materials. What I have seen of the deltas of burns in the Highlands leaves me no room for doubt that these masses have proceeded from Strathbran. The fact is evidenced, *inter alia*, by the slope of the whole alluvium up to a certain point in that glen; whence it happens that the terrace above Inver is 13 feet higher than that at the villa of Hillhead, above Dunkeld. In Strathbran there are several fragments of higher terraces.

hillock rising abruptly out of the low plain somewhat in the shape of the letter L, having a top of 156 Scotch acres in extent perfectly flat, and precisely the same height as the terrace; in fact, the whole merely an outlying fragment of the higher alluvial plain—a relic surviving the degrading agency by which the rest had been swept away. It is called *Inch-tuthil,* "the island of the flooded stream," a name supposed to speak of its formerly being surrounded by a division of the Tay. The Picts had a town and fort at one of its extremities. Investigators of Roman-British history tell how the conquerors of the world had their great camp called *In Medio* on this Inch-tuthil, and how they retired hither after their conflict with Galgacus. Traces of these fortifications and many tumuli of the dead are, or recently were, visible on the surface. It is a valuable object in the present inquiry, as exhibiting a link between elevated alluvial plains in their entire form, and fragments so far reduced as the Bass at Inverury and the Mounts of Dunipace on the Carron.*

52. We shall now proceed to the expanse of the Tay valley which intervenes between Dunkeld and Logierait. Mr Maclaren has remarked its being

* Inch-tuthil is particularly described, with a map, showing the traces of the fortifications, in Pennant's *Tour through Scotland,* Part ii. 4to, 1790. It is unlucky that modern taste covers Inch-tuthil and similar objects with plantations, which in more ways than one preclude their examination, besides obliterating their natural as well as artificial features.

fringed with terraces all along, particularly on the east side. These terraces are wholly composed of gravel. The road passes at the bases of those on the east side, sometimes rounding promontories, on the tops of which we see farmsteads perched, with their little stackyards. At some places we see two or three rising above each other, but generally one is more bold and conspicuous than the rest. At Logierait, the Tummel vale joins that of the Tay: both are alike skirted with gravel terraces, and at the point of high land between, these form a small elevated plain, presenting the remnants of a *rath* or aboriginal fort, from which the parish takes its name. By the best measurements I could form with the assistance of the plans of the Perth and Inverness Railway, this small elevated plain, and the leading terrace on the opposite side of the Tummel, are 281 feet above the sea, belonging to the same era of sea-level as the terraces at Dunkeld.

53. In proceeding along the vale of the Tummel, terraces are every where observable. On emerging from the narrow rocky defile of Killiecrankie, we see the Garry permeating a plain similar to that of the Tay below Logierait. A haugh by the wayside is partly the scene of the battle which Lord Dundee fought with the troops of William and Mary, and in which he lost his life. But local historians tell that the fighting chiefly took place on the high ground above, at Urrard House. This high ground is at

once perceived to be one of the gravel terraces so conspicuous throughout the Tay basin. Its surface, all under cultivation, is not very regular; but, taking average elevation, and using the levels of the Perth and Inverness Railway, I make it 497 feet above the sea, being the height of a terrace which makes some very large presentments in other districts of Scotland. It may be set down that *Gramius Notabilis* received his death-wound on the 497-feet beach.

54. Onward to that scene, so worthy to be the abode of a Highland kinglet or prince—Blair-Atholl—a magnificent plain encircled by rough woody hills, some of which are of great height, and on the skirts of one of which is seated the chateau of the Duke. The Blair or Plain of Atholl—for it is from this plain that the place is named—is one of those great haughs which I have generally found to be coincident with the heights of some one of the series of beaches, being in fact the temporary terminal points or heads of estuaries, and formed either by the sea cutting down old alluvia to a new level, or by detritus brought in of new by the river. It extends for miles with very little inclination, and is headed at Bruar by older and higher alluvia, which stoop abruptly down to it. Having found this great haugh generally a little under 500 feet in elevation above the sea, it appears to me as probably connected in its origin with the Urrard terrace.

55. To return to the Tay at Logierait. Its valley as far as Grandtully is marked, according to Mr Maclaren, by tiers of terraces; afterwards, for some miles, they are less developed. In the first tract, the river, as remarked by that acute observer, runs across the strata, and the sides of the valley are steep, rugged, and picturesque; in the second tract these circumstances are reversed. Mr Maclaren is in doubt whether these terraces be connected with those farther down the valley, in which case they would be on an inclination. The proofs against any true memorials of ancient sea-margins in Scotland being inclined in the direction of their length, are overwhelming; and I therefore take it upon me to say that these are not continuous terraces following in any degree the fall of the valley or the river. It often happens, however, that such terraces near the openings of side streams are inclined, being in that case relics of the deltas of the side streams, and sloping for the same reason that a cartful of gravel tumbled on the ground has sloping sides. In such cases only the highest point is properly connected with the ancient sea-margin.

56. Mr Maclaren mentions a terrace about 35 feet above the river where it issues from the lake at Taymouth, and on the western extremity of which the village of Kenmore is situated. Loch Tay being 350 feet above the sea, this terrace must be about 385, about the elevation of a very noted

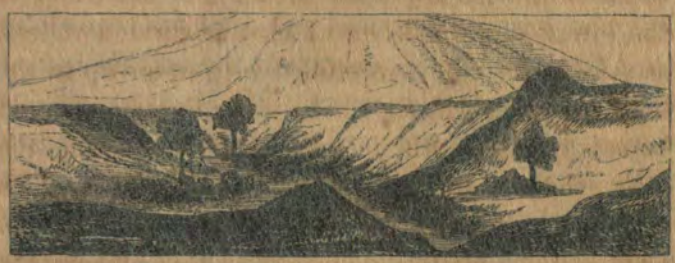
terrace prevalent in Scotland, and also found in France, as will afterwards be more particularly noticed.

57. Not far from Kenmore, the Tay valley is joined by its wild and unfrequented offshoot, Glen Lyon, which you may penetrate for thirty or forty miles, even unto the borders of the Glenorchy wildernesses, passing through narrow rough defiles, where tradition points shuddering to chasms leapt of yore by pursued outlaws, and where, from the very loneliness of the district, you still find Fion's castles and the fanes of the Druids in unwonted abundance and entireness. Even here the eye of the geologist readily finds memorials of the former presence of the sea. At a gorge near Culdare, a large tract over which the road passes is deeply covered with rounded shingle about the size of cocoa-nuts. You pass under the bases of great terraces which at every breach of the surface you see to be composed of smaller gravel—here a gentleman's mansion seated upon one, there a lonely burial-ground deserted of its church upon another. There they are, one level after another as you go on, the product of the fierce streams which still seam the sides of Ben Lawers and Carrickvar, as they were laid down ages ago in the narrow sound which once glassed these tremendous mountains; and all, doubtless, coinciding in levels with those kindred memorials of ancient seas found in so many other regions, though seldom

in any, where the tale they tell may sink deeper into the meditative spirit.

58. In Glendochart, the upward continuation of the Tay valley from the head of Loch Tay, rude irregular terraces of gravel and sand are seen along the skirts of the hills, generally in the neighbourhood of the mouths of side-rivers. Mr Maclaren alludes to one of these, "not very well marked," about two miles north of Killin, which the sympiesometer (an instrument not sufficiently precise for such a purpose) made 240 feet above the loch. Mr Maclaren looked among the gravel terraces of Glendochart for fragments of granite, as a test whereby to ascertain if any far-travelled rocks were included in these deposits; but he did not discover "a single piece even of one foot diameter." This is not surprising to me; for after examining the gravel deposits of many Highland glens, the local nature of their origin becomes more and more evident. They are, as just remarked, most abundant near the mouths of side-glens. They are always most so where two or more glens unite, as is sometimes the case near the head of a great valley. At places where there are no accessory rivulets, the sides of the valley are either unfurnished with such fringings, or these are only the tails or continuations of burn terraces, or else the meagre results of the washing of the sea on the mountain side. The gravel deposits at the openings of side-burns are a feature of such importance in the

Highlands as to be worthy of particular notice. At Corryheurich, in Glendochart,* we have a notably characteristic example, of which a sketch is annexed.



ANCIENT DELTA OF CORRYHEURICH BURN.

From 100 to 200 feet above the base of the valley at that place, sloping terraces spread out along the sides of the little glen through which the Corryheurich burn descends. Each corresponds in height and slope with one on the opposite side. One of the higher and more entire extends along the principal valley for a considerable way, with a slope which terminates in nearly a flat. The lower are less entire. The whole bear a rude resemblance to the seats in an amphitheatre. It is remarkable of many of these formations, that the opening between the terraces is slightly turned *down* the principal valley; and the terraces are usually most entire in that direction, while on the opposite side we are likely to find the greater masses of the material, but

* Between Luib Inn and Loch Dochart, on the south side of the valley.

in the form of hillocks, hummocks, or otherwise ill-defined accumulations. We shall afterwards have occasion to remark that, in Glenroy, one or two of these formations adjoin at their upper extremity to the lowest of the shelves of that celebrated valley; so that if the valley were filled with water up to the height of the shelf, the whole of the formation would be subaqueous, with its apex exactly meeting the embouchure of the little rill connected with it. This gives a clear hint of the origin of such a formation. Composed of matters delivered by the rill into the water-filled valley, it was at first a *talus* forming a portion of a circle. The water sinking away to a lower level, the upper part was exposed, and now the burn runs over it. The burn cuts down through the soft material, and at its new embouchure the sea makes an opening. With new and old materials, a new formation similar to the former takes place. This, on a subsequent lowering of the sea, goes through the same history; and, finally, the main valley being entirely deserted by the sea, we see only the wings of all these various formations—*a series of deltas intersected*, each delta representing an era of the shift of relative level, but one in most cases not easily ascertained, in as far as the formations are so fragmentary, and often so obscurely connected with the more plain-spoken memorials of ancient sea-levels. The magnitude of these detrital masses is apt at first to surprise us. But when we

consider that they are generally under 700 feet above the present sea-level, often much less, and that the mountains in the Highlands are from 3000 to 4000 feet in height, so that an ample course, and that through the steepest ground, remains for the burns, we readily see that surprise may be dismissed.

59. The Corryhounan burn, which joins the Dochart a little above the ancient Priory of St Fillan's, presents two fine sloping terraces on the side towards the lower part of the principal valley, while on the other side is a large hillock. A little farther up, two streams descending from the skirts of Bendouchrick join the water which passes Tyndrum Inn, and there, accordingly, we find a grand collection of terraces. Amongst them, I was able to distinguish as many as four several elevations. It was on a small alluvial flat at the bottom of these terraces called Dalrie (the King's field), that Robert Bruce was obliged to fight a battle, in the days of his greatest distress, against his noted enemy, John of Lorn.

## FIFE.

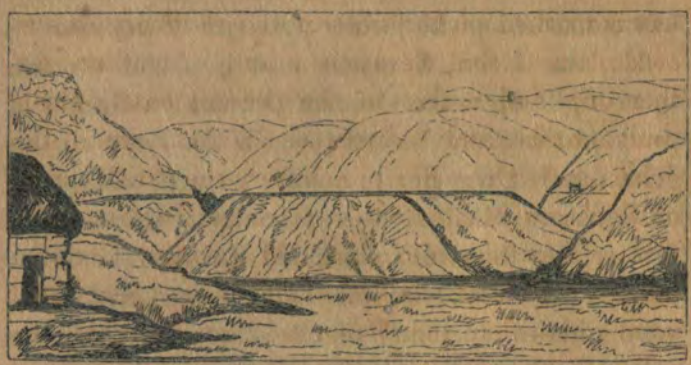
60. The county of Fife—a sandstone district so tossed up with trap that it might be compared to a blanket laid over nine-pins, interposes as a peninsula between the firths of Tay and Forth. Its northern

border towards the Tay we have seen to be marked by an ancient sea-margin at 56 feet, and some others. Its southern frontier along the Firth of Forth is similarly marked, and in the valley of the Eden, which traverses its length centrally, there are many features recalling the former presence of the sea.

61. The Eden, a gentle and beautiful stream, opens right upon the German Ocean;—a district of sandy plateaux on the left towards the Tay; on the right, towards the Forth, a lofty terrace backed by gently rising hills. At the extremity of this terrace, four or five miles off, pinnacled St Andrews looks out upon the sea:—an anciently civilised and cultivated district, speaking of Christianity both in its Romish and pre-Romish forms, of royal hauntings, and of the commerce of a bypast condition of the country. But it has a history, compared with which the chroniclings of a Wirton and a Bower are as the news of yesterday.

62. In the space between the Eden and Tay, a little stream called the Mottray comes down from the hills about Kilmany, to make an unobtrusive junction with the Eden just at the place where it falls into the sea. Throughout the latter part of the course of the Mottray, from Kinnear down to Leuchars—a space three or four miles in extent—there are terraces, and hills in the form of low truncated cones, composed of gravel and sand, and all coming to one height—namely, about 107

feet above the present sea-level. Stand on the verge of one of these eminences, with the eye level with their flat top, and, looking round, you see but one plain. The great hollows between the various



PLATEAUX NEAR LEUCHARS.

masses have evidently been at one time filled up, so that the whole formed one plain in reality. This is the wreck of a detrital formation dating from the era of the sea which stood somewhat more than 107 feet above the present—that noted sea which also formed the grand terrace between Perth and Luncarty (§§ 45, 46). While partly derived from the trap and felspar district traversed by the burn, the materials lead us to suppose that the greater part was washed from the Old Red and Carboniferous cliffs of the neighbouring coasts, brought and piled up in what was then a sheltered bay, as similar matters are brought and laid down on the far-stretching *sands* of

St Andrews at this day. Sinking gradually to other levels, the uneasy element, with the aid of the stream, ate out these hollows, leaving only portions of the original surface entire. But its retirement has not passed unnoted. At several places, a terrace of about 70 feet is marked on the sides of the residuary masses, or a plain of that elevation is left. At others, farther out, and nearer to the present coast, plains, promontories, and terraces of 56 feet, are distinguishable.* On such a promontory the parish church of Leuchars is situated—a piece of Norman architecture, reputed, of course, old amongst Christian temples in Scotland, yet younger—by how much younger!—than the youngest of our terraces. Finally, there is a flat bordering the sea at 20 feet, bearing the old ruined castle of Earlshall. When Alexander Henderson sounded the trumpet-call of the Covenant at Leuchars, to bring musters to Dunse Law, he little thought of the age of the terrace on which he stood, in comparison with that which bore the house of the then faithful Bruces, his neighbours and patrons!

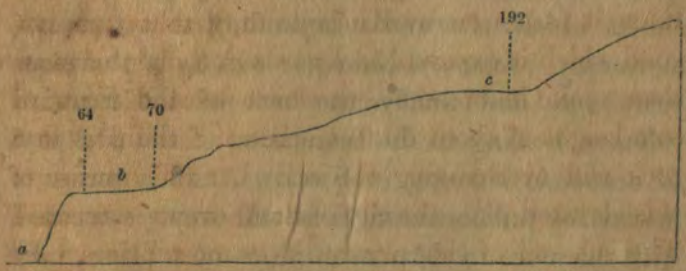
63. Let us now turn to the district skirting the mouth of the Eden on the right. Here the grand feature is also a memorial of the 107-feet level, as

* Amidst these plateaux, there rises a low trap eminence between Fordel and Craigie. It is covered with gravel of the primitive rocks, which a local geologist contemplates as brought from the Highlands, most probably by ice.

it may be roughly called, but in the form of a terrace along the face of a more elevated country. Commencing above Nydie, in the very throat of the Eden, it passes on by Kincaple to Strathtyrum, beyond which it expands backwards in a plain of more than a mile in breadth, but which descends seaward to a height of about 56 feet, when it terminates in a rock cliff overhanging the sea. At the frontier of this elevated plain the city of St Andrews is situated. The sub-soil of the plateau is in most places pure sand. We must here concentrate attention on the immediate adjuncts of St Andrews.

64. A sandy plain, rising from 56 feet at the front cliff, to about 117 feet at the place, more than a mile off, where it abuts against the rise of the hills; this resting on a platform of the lower part of the carboniferous formation, full of shifts of inclination—these are the leading features. Wherever this plain is dug, a deep bed of stratified sea-sand is found. A rill, called the Kiness burn, cuts through sand and sandstone to the south of the city, but only to make the case more plain by the coincidence of the upper edges of the valley so formed. The low inclination reminds us of a tidal slope; but a tidal slope of 60 feet in vertical rise appears a startling idea. Narrow examination, however, makes the matter intelligible. At the east extremity of the plain, near St Nicholas, where the eminence called Brownhills comes boldly up to the sea,

it is observed in a form like that in the subjoined outline, at a height of only 64-70 feet. At another




*a*, Sea-level. *b*, Ancient beach, near St Nicholas. *c*, Higher beach at Brownhills farmstead.

place—Balgove farmhouse—a mile and a half distant, the higher ground makes a similar bold advance, and there, too, the terrace is only about 70 feet: an escarpment succeeds, and over that a second terrace, though of small extent, at 107 feet. The explanation consequently is, that at St Andrews, as at Carnoustie (§ 36,) owing to the gentle character of the ground, the sea has made several shifts of level without indenting the land. Resting on a slope of such low inclination, its cutting or indenting force had little effect. But the escarpment at Balgove is a proof that it made a rest at the same height behind St Andrews. And, after all, when the ground is narrowly inspected, some slight tracings of such inequalities are observable in several places over what appears at a cursory glance as a uniformly inclined plain.

65. It was doubtless the smooth and fertile nature of this plain which determined the selection of the spot for a religious establishment—that cell of Greek monks which, afterwards expanding to a Culdean monastery, became a bishopric exactly a thousand years ago, and finally the seat of the Scottish primacy, leading to the foundation of the first seat of academic learning in Scotland, and a series of interesting public transactions and events connected with the more modern revolutions of religion. All this, because it was a place over which the sea had risen and fallen, during many ages, ere yet the more restless tide of hope and fear had begun in the human breast.

66. To the north-west of St Andrews, the cliff retires from the sea, and, making a sweep under Strathtyrum House, leaves a low sandy tract between it and the tide-line. Part of this low ground is a sea-formed plain of about 11 feet (§ 12,)—one of the last of the ancient beaches. A stripe nearer the sea—well known under the name of the Links, and the chief ground for playing the game of golf in Scotland—is lower and of less regular surface, being most probably composed of wind-driven sand. It abounds in shells of the current era, insomuch that, in a piece of broken ground on the golfing course, it is difficult to find a ball which falls upon it, both being alike white. At the very edge, towards the sea, there is a kind of sand-wall, of from

10 to 15 feet high. The sea is on the whole losing ground in this quarter, for not only has a stripe under Balgove been lately gained for culture by some help from embanking, but it is known that a good way back from that line, there were salt-pans in the middle ages, where now are corn-fields, but certainly (as I have myself tested) of very slight elevation above the present sea, and that little only such as might be the effect of accumulations through the force of winds and waves.

67. In the receding or *bay* form of land above the plateau at St Andrews, there are several broad and well-defined terraces, though not so perfectly recalling a tidal slope of the present era as that which has been described. One of these begins at the farm of Pipeland, and runs eastward to Brownhills, where it terminates at the base of a higher plain, being, in places where it is entire, 165 feet above the sea; the soil a deep layer of palo clay, with some sand on the surface. This broad and palpable terrace meets but a local interruption at Brownhills. If we pass round the eastern portion of Fife to Crail, we find the same terrace running along the country, at precisely the same height above the sea: it is well-seen at Easter Pitcorthy, at Balhouffie, and Ovenstone, where its extensive fields lie with such an inclination for exposure and drainage, as must add considerably to their value.

68. On the face of the slope, a little below Pipe-

land farmstead, there is a small crust of a terrace, sufficiently distinct to have become a natural demarcation between fields: this is about 126 feet above the sea.

69. Higher up, and more to the west, commences another terrace—one a good deal cut down by rill-courses, yet sufficiently distinct; the farmsteads of Lumbie and Balone upon it; traceable as far as Mount Melville gate. This flat is 203 feet above the sea. Higher up still, is another step of the sea-stair—the site of Feddinch Mains farmstead, and of Mount Melville House; about 325-330 feet. A mile to the westward, at the village of Denhead, there is a much grander terrace at about 465 feet, with a fine bold frontier to the valley below, and a deep cut therein for a little burn, a fairyland of furze-blossom and daisies, and doubtless the source of the name of the village. This terrace continues for a couple of miles westward, affording site to the villa of Denork, and terminating near a place called New-

PLATEAUX NEAR DENORK.

biggings. On the rise of the ground over its western extremity, is a remarkable floor-like field, the outline of which has a conspicuous appearance from a distance in both directions; this is 545 feet above the sea. Some things relative to these will be afterwards particularised.

70. The frontispiece of this volume will help to complete the reader's conception of the St Andrews terraces. We are seated on the sand-wall near the sea. In the foreground are the Links and the low tract which has been spoken of as an 11-feet beach. Then comes the lofty though softened cliff under which the 11-feet sea has beat; at the top of which appears the great inclined plain, rising to 117 feet at its inner extremity; a suburb of St Andrews seen on the left. Over that suburb is the Pipeland terrace, which extends much beyond the limits of the picture to the left. Higher still, on the right, is the Lumbo and Ballone terrace, over which a few fainter markings are seen, particularly the line at Feddinch Mains. It may be added, that on the Anstruther road, behind the hill on the left, a tract of flat ground appears at from 280 to 293 feet.

71. The valley of the Eden now comes under attention, a fine open expanse of perhaps 25 miles in extent, bordered by ranges of hills of moderate elevation. The basis or bottom of the valley is an alluvial plain, containing much gravel and sand, and preserving throughout a remarkable uniformity

of elevation, being in few places much above or below 120 feet from the level of the sea. This is, of course, the bottom of the ancient estuary of the Eden. All along the skirts of the hills, on both sides, are patches of ancient sea-borders, terraces, and hummocks of sand and gravel.

72. The bottom alluvium of the Eden vale terminates in steep curvilinear banks about a mile above Cupar, the open of the curve or crescent being presented down the valley. A nursery on one of the cusps of the crescent is generally sandy in its consistence, but not without some clay. Some strong fragments pass farther down, but at a lower level: one forms the Castlehill of Cupar, noted as the place where Sir David Lyndsay's satirical *morality* was acted before the Scottish court, anno 1535. Others appear below the town—at one place cut through by the Edinburgh and Northern Railway, so as to show at least 30 feet depth of pure sand and gravel.*

* In Dura Den, a short side-valley which joins the Eden vale at Dairsie, are several alluvial flats, which a measurement, somewhat less certain than usual, brings into a rude harmony with the terraces of neighbouring districts. Near Dairsie church the Eden is bordered to the north by a bank flat at the top, and 64 feet high. At the church, we stand on a plateau of gravel 107 feet above the sea, and see similar plateaux on the opposite bank of the Eden, at the bottom of the Dura vale. A parallel line is formed, close above these plateaux, by another at 128 feet, in which a pit reveals its composition of pure sand and gravel—the whole being, of course, the spoils of the Dura burn.

In the more open part of this valley, between Pitscottie and Ceres, where the bottom or basis is a flat at about 170 feet above the sea, a faint

73. Of the terraces bordering the vale, an interesting series is traceable at Falkland, ten miles to the west of Cupar. This ancient burgh is seated on an irregular piece of ground, under the shade of the Lomond Hills, and at a small elevation above the

terrace at 203 feet appears on the north side: Ceres Mill and the Kilnhill, or Gallowhill, are places upon it. To the west of Ceres, on the south side of the valley, is a flat elevated line of country, along which the old road proceeds—the way by which Archbishop Sharpe was travelling when he was observed by his assassins. Seen on the opposite side of the valley, at Wemyss Hall, it resolves itself into a pretty distinct line. It is 465 feet above the sea. A flat at a place called Findas, beyond Struthers Castle, is the same height. These lines consequently correspond with the Denhead and Denork terrace (§ 69.)

A minor vale, permeated by the Teasses burn, and extending to the south of Ceres, is a nest of terraces. One, constituting the original basis

TEASSES VALLEY, FROM WOODBURN.

of the valley, is at 345-8 feet; another is at 386; a small but significant flat occurs at a place called Fleecefaulds, 442; a bracket over this, marked by a small plantation, 545; a projecting platform at a hamlet called Back Brae of Teasses, 573; and, finally, and most remarkable of all, there is a great terrace at East Hill, 514 feet. The flat sky-line at the top of the valley, marked by a solitary tree, is 599 feet.

basis or bottom of the valley. Starting from the banks of the Eden at Dunshelt, we pass a mile over ground almost perfectly flat, part of the hunting grounds of the Scottish kings in old times, but now covered with fertile farms. We then breast the low but abrupt face of a higher alluvial plain, immediately skirting the bottom of the hills. This is strictly 21 feet above the preceding flat. It has all the usual marks of an ancient sea-margin, with this in addition, that a naked sandstone cliff overhangs its inner border. When the sea had its margin here, the waves would beat at the bottom of the precipice, and perhaps prove the cause of its standing up in so abrupt a fashion. We now ascend 43 feet along the slope of the hills, and find a broad flat terrace stretching about a mile to the east of Falkland, forming a fine series of cultivated fields. A rill descending from the skirts of the Lomonds has cut it down, and even worn out some of the subjacent rock, and in this section nestles the old burgh, with the hunting-palace of the Roberts and the Jameses. On the face of the hills above the kirk and manse of Cults—the braes which Wilkie roamed over in his childhood—there is a series of terraces, superior in elevation to the Falkland group, and which have a conspicuous appearance from the road.

74. Some features of the high grounds of Fife are worthy of particular notice. The eastern district, between the Eden and the Firth of Forth, is a

long gently descending slope, divided by a wide hollow of gently sloping sides, in which runs the Kenly burn. It is remarkable that, notwithstanding this wide division, the outline of the country is unbroken; so that when we breast the eminence on the St Andrews side, we see the surface of the more remote ground at the same instant. What is more curious, a solitary little hill which starts up out of the intermediate hollow at Dunino, and which Fraser in his map of Fife sets down at 370 feet above the medium level of the sea, comes up exactly to the same common line. The natural inference is, that the whole sheet of sloping ground took its form under some common cause, and that Dunino Hill is the remnant of some mass once identified with the rest of the ground, but which was subsequently worn in a great measure away. Another case of coincident outline occurs in the high grounds to the west of St Andrews, the slopes being easterly in both cases.

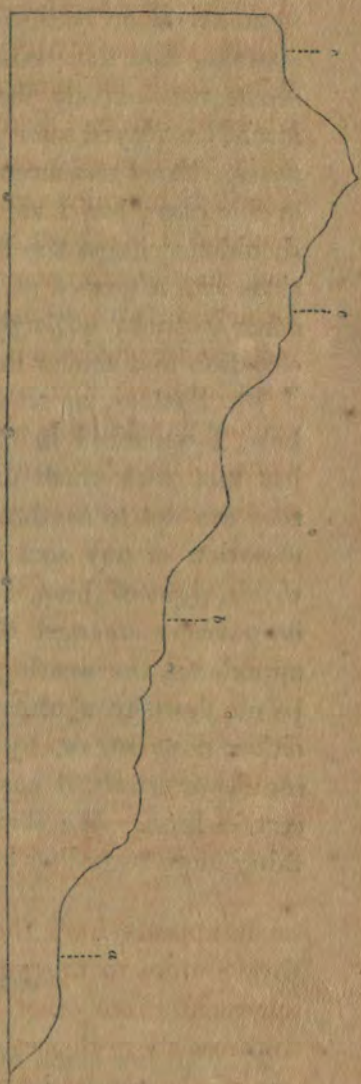
75. It was among the hills in the eastern district of Fife that I first observed certain other coincidences speaking strongly of the working of the sea at ancient levels. There are, on the faces of many of those hills, platforms or resting-places, not at all describable as terraces, for they want longitudinal extent, but yet presenting a remarkable horizontality of general outline, and in many instances covered with such soft materials as are found on ancient sea-margins. They probably, in general,

occur at places where soft and hard strata meet. Where the sea-surface has met a set of soft strata, it has made an indentation in the side of the hill; where it has met hard strata, it has had no such effect, and consequently left the hill unmarked. Tarvit Hill, which overhangs Cupar, and the West Lomond Hill above Falkland, are *graduated* (if I may use the expression) in a notable manner. The former, as we ascend it from Cupar, presents a steep and equable slope, till, approaching Tarvit Hill farmstead, we find a broad flat of well cultivated ground extending a considerable way in both directions. The accompanying sketch shows it in outline

MARKINGS ON TARVIT HILL, &c.

as it appears from the neighbourhood of Fruchie, 7 or 8 miles to the westward. By the aid of measurements from other authorities, I make this flat 466 feet above the sea, which is about the height of one of the regular terraces throughout the country.

Another, less regular, appears above the farmstead — conspicuous everywhere to the north and east by two solitary trees growing upon it—this is about 543 feet above the sea, being also the elevation of one of the regular terraces. Now this is the place where the sandstone, which forms the chief mass of the hill, terminates, all the rest being of trap. The West Lomond Hill has a like sandstone base; then a stratum of greenstone 100 feet thick; then thin beds of limestone; and, finally, a thicker mass of greenstone; all disposed with slight inclination. Its northern outline, as seen from the eastward, presents the appearance conveyed in the accompanying outline. Structure, while accounting in a great measure for these features, does not do so entirely, for one occurs at the



OUTLINE OF WEST LOMOND HILL, as seen from the East.

same height on both sides of the hill (*c c*), notwithstanding that the stratification is not horizontal. It seems not unlikely that the sea, at various former levels, has played some part in producing the appearances. Exact measurements have not been attainable in this case; but I am satisfied that the first great shoulder amongst the Nuthill woods (*a*) nearly coincides with a terrace at about 758 or 60 feet, seen in other districts, while the second (*b*) is very near in elevation to a similar marking at 996 feet.

76. Further, as to these rests in the ascents of hills, I remarked in this district—and the remark has met with much to confirm it elsewhere—that they are apt to conform in elevation to the general elevation of any sort of table-land which may be within sight of them, and also to that of land-straits or passages amongst the hills. In the one case, I apprehend, the wearing agency has brought various points down to a uniformity. In the other, it has either done so, or, by deposition of soft matter in sounds or straits, it has brought the ground up to a certain level. We shall have occasion to say something more regarding land-straits in the sequel.

### STRATHSPEY.

77. The low lands of Moray, extending for many miles along the firth of the same name, are wholly

composed of beds of gravel and sand, the spoils of the Highland rivers Spey, Lossie, Findhorn, and Nairn, brought down and deposited there when the sea stood at a considerable height above its present level. The vast size and extent of these accumulations is striking to the most unobservant eye: it might be said there are *gravel hills* in Morayland. The magnitude of the deposit is seen to be owing simply to the comparatively great extent of alpine country drained by these four rivers and their tributaries. At this day, they are continually bringing great quantities of gravel into the sea, which from this cause is always getting more and more shallow. At the mouth of the Spey, the spoil is formed by the joint action of the sea and river into ridges, which greatly impede navigation.* Of such ridges there are several examples on the dry land between

* "A large quantity of gravel is brought down the river during every flood, and forms into ridges at the water mouth, often rendering access into the harbour [of Garmouth] impracticable, except for vessels of small burden. . . . Since 1815, the depth of water in the bay, for about two miles out, has diminished one fathom. This will give an idea of the quantity of gravel carried down by the stream. From beyond the bridge of Spey, the gravel over which the river flows is continually in motion, and rapidly descending to the ocean; in proof of which I may mention, that several large stones, which formed part of the bridge of Spey, were cast ashore at the water mouth, four days after the bridge fell on the 4th August 1829; and the mooring-anchor, weighing at least a ton, and securely fastened, as was supposed, in the channel of the river, a quarter of a mile from its mouth, was, during the great flood, carried out to sea, and never recovered."—*Statistical Account of Scotland, Art.* Speymouth.

the mouths of the Spey and Lossie—precisely such objects as the ridges now within the sea-mark would form if they were raised permanently above the waves. There is also a district between Elgin and Lossiemouth, where the gravel is, for the most part, laid down in equable plateaux at a low level. One of them is but 5 feet above what is called the Lake of Spynie, a morass into which the sea at no distant period entered. Another is 10 feet higher. Great flats, bounded by low banks and escarpments, may be said to constitute the conspicuous external feature of the district. Near the sea at Lossiemouth, we see the gravel of the lower plateau extending over many acres, composed of rounded stones of the size of cocoa-nuts, without a blade growing amongst them, and only serviceable as a store whence to repair the roads.*

78. We have spoken of the *gravel hills* of this district. When three of them—the Black Mount, Quarrywood Hill, and the Knock of Alves—are specified as 280 feet high, the reader may judge whether the expression is justified. The Black Mount, which stands well out towards the sea, has precisely the appearance of such mounts as those of Dunipace and Inverness, which are now generally set down as the remnants of ancient alluvia of great

* See § 19, for an account of some alternations of marine with fresh-water deposits in this district.

extent, which originally rose to the same height. So much is this the case, that, on first seeing it at a distance, I ventured to predict both its being formed of gravel and its long flattish summit being of the height of one of the ancient sea-levels which I had ascertained elsewhere; both of which predictions proved to be strictly true. If we are to suppose that a gravel sea-bottom or beach of this elevation once overspread the district involved by these hills, we must presume that the quantity of matter swept from the interspaces into the further depths of the sea was even greater than that which remains. The probability, however, is, that the ancient sea-bottom was not everywhere filled up to the same height, but that such dense deposits were more or less local in connexion with the more immediate neighbourhood of the mouths of the rivers. It is worthy of remark that terraces exist on the seaward face of Quarrywood Hill, indicating the working of the sea at at least two lower levels.

79. At Covesea, a cliff of Old Red sandstone, only a few feet higher than the three hills mentioned, interpones between the low gravelly plains and the Moray Firth. The precipice rises, on the immediate borders of the sea, to the height of perhaps 100 feet, and yet is so much removed from the influence of the waves, that a date inscribed by some visitor, "1749," is still seen fresh and deep upon the face of the sandstone, though that is not of a hard tex-

ture. While scarcely touched by the sea even at its base, this lofty cliff is marked in every part of its surface by the wearing effects of that element; caves cut into it, and curious arches, and perforations little and great. You wander through a kind of arcade under this strange cliff, admiring the lofty roof, the fantastic openings resembling doors and windows, and the hollows chiselled out, sometimes leaving a curious tracery over them like the leaf sculptures on the capitals of pillars in an ancient Gothic church. In a recess or bay, stands a huge mass isolated on a double base, one limb of which is much worn away, so as to convey a startling idea of instability. One cave, in which the Gordonstown family kept their horses in 1745, to conceal them from the insurgent Highlanders, is walled up in front, leaving a door and window. Another cave was not long ago discovered, from 17 to 20 feet above the sea, containing sand, shells, and pebbles, as they had been laid down when the waves reached to that height, and also a superficial bed of matter in which were relics of beasts, birds, and fishes (among the rest, bones of the beaver and crane, now extinct in Britain), supposed to have been brought thither at some intermediate time by predaceous animals.* These circumstances conspire, with the appearance of the cliff, every where weathered in an extraordinary manner, to

* Duff's Geology of Moray, p. 8.

render Covesea an object of singular interest, well worthy of greater attention than I was able to bestow upon it.

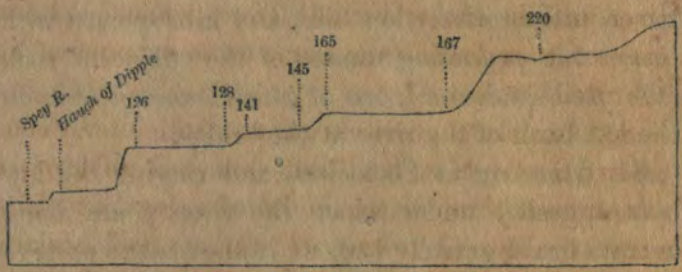
80. The Spey debouches from the high country two miles to the south of the village of Fochabers, and about six from the sea. All after that is a sheet of gravel and sand at different heights, confined between comparatively low hills, and interspersed with one or two projecting masses of the subjacent rock (Old Red sandstone), one of which is conspicuous on the left bank of the river at the bridge.

81. Standing at Fochabers, and viewing the low hills opposite, under which the river pours along over its broad gravelly bed, we cannot fail to observe the several terraces rising one above another on the lower part of the face of those hills. On a nearer examination of the place, it is found that, at the

TERRACES OPPOSITE FOCHABERS

base of the hills, there is a perfectly smooth alluvial

plain, extending from above a point opposite Fochabers, down to near the sea, and following in that direction a very low angle of declination. A village called Crofts of Dipple is seated upon it. Towards the river, it terminates in an abrupt and steep descent, at the base of which is a spacious haugh.




SECTION OF TERRACES OPPOSITE FOCHABERS.

On the other side, rises the hill with three terraces, forming straight parallel lines of an almost artificial aspect. With the aid of some measurements by a friendly professional hand,* I am able to determine the heights of these various alluvial plateaux and terraces, as they appear in the section.

82. The vales of the Moray rivers are all of them full of similar markings. On the banks of the Nairn, at Daviot Kirk, nine or ten miles south of Inverness, the place where the great north road crosses the river, huge masses of gravel in a rudely

* Mr Alexander Marquis, land-surveyor, Fochabers.

terraced arrangement are seen on the sides of the valley, being the remnants of deltas formed by the side rivulets. They are said to be somewhat more than 600 feet above the sea.* I have not had opportunities of carefully examining any other portion of the Spey valley besides the district around Kingussie, about fifty miles from the entrance of the river into the Moray Firth. The phenomena, however, of that district may serve as an example of all the rest.

83. Imagine a great expansion of the usually contracted limits of a Highland valley; a noble river pressing on through the midst of a low flat plain, scarcely elevated above its waters, and actually submerged by them on all occasions of *spates;* on each side, a range of brown hills, rising to the height of from 3000 to 4000 feet. All around, the rising grounds are fringed with straight-lined terraces, at some places single, at others double and even triple-tiered, and always presenting steep escarpments towards the river. On the front of one, which advances as a promontory does into the sea, sits the imposing ruin of Ruthven Fort, an erection of the early Brunswick reigns for the suppression of the cavalier spirit in the Highlands, and the place where a faint last effort was made in 1746 to rally the broken forces of the fated Stuart. These terraces

* New Statistical Account of Scotland, Art. *Daviot.*

are on both sides of the river, but they do not always correspond in elevation,—as might be expected, indeed, from what we see of either side of the valley; for, in glancing along any mile of that space, we observe a terrace of one elevation at one place, and another at a different elevation at another. A curious and striking scene it is altogether, and one which certainly stirs in me great wonder, that no one ever till now attempted to read in it any generalisation as to a point in the past history of the surface of our country.

84. These terraces are all severally connected, of course, with rests of the sea at former elevations; but it is difficult, as to some of them, to fix their height above the present sea-level, seeing that they slope up to the openings of side-valleys,—are, in short, fragments of deltas. Some, however, are less equivocal; and these I shall include in the following general view of the sea-markings of the district.

85. The meadow or haugh, just alluded to—a magnificent example of its kind, stretching with little interruption for miles down Spey side, may be described as from 714 to 720 feet above the level of the sea at mean tides.* A terrace at the boat house of Kingussie is 761. Two undisturbed terraces on the opposite side of the river, under a place

* In ascertaining the levels of this district, important aid was derived from the plans of the Perth and Inverness Railway, and notes therefrom kindly furnished by the engineer, Joseph Mitchell, Esq. of Inverness.

called Knappoch, are respectively 792 and 829. Another to the east of the castle is 853. One of great prominence at Nuid, more than a mile above Kingussie, is 868 in its fore part, and probably rises a few feet more. A mass behind the inn is 808. A mile down the valley, its left side presents a grand terrace, on which is seated Belleville House, the mansion of the poet Macpherson: this, being ascertained by levelling as 121 feet above the river, is probably the same sea-marking as that above cited at 830 feet above the sea. It may here be remarked that, at Aviemore, there is a terrace on the face of Craigellachie, strewn with boulders, and having a mate on the opposite side of the river; the elevation 776 feet.

86. In the physical geography of a Highland valley, one pretty frequent feature is a long horizontal line a good way up the hill sides, being the separation between the cultivable land below, and the bare rocky hill rising out thereof: sometimes it approaches the character of a terrace, or fully realises it. An example is presented at a place called Drumgellavy, opposite to Kingussie. It is 997 feet above the sea, and there is something of a different aspect relative to it on the other side of the valley. Just behind Kingussie village, in a rough little valley called Glen Goinach, after ascending rather more than a mile, we find the relics of a large delta sloping up beside the rivulet towards a particular point, which is precisely the height of the Drumgel-

lavy line or terrace. Close by this spot, a line of singular appearance passes along the hill-side, at the same level, which, on minute investigation proves to be merely a change in the vegetation—much heath below, much long yellow grass above; a meeting of two regions botanically somewhat different. When I found, by a careful use of the spirit-level, that this line coincided in the most precise manner with the line of change from soil to rock at a distant spot on the opposite side of the valley, I felt how beautifully all true sciences harmonise, and what important light one will throw upon another. The line in Glen Goinach is a demarcation between soils, the diversity of which has resulted from different circumstances attending the working of the sea when it stood above and at that level. Farther back in this side valley, round a little lake, there are alluvial masses commemorating ancient seas at 1104, 1131, and 1261 feet.

87. At the distance of eight miles, at Ettridge Bridge in the subordinate valley of the Truim, there is a conspicuous true terrace skirting the water, and 997 feet above the sea. Thus there is every kind of memorial of this sea-level in Strathspey. Others at this place are 1028, 1052, and 1075. There is a terrace at Phones, which Sir David Brewster pointed out to the attention of Mr Darwin: I have not seen it; but, as the plans of the Perth and Inverness Railway indicate an elevation of 977 feet for the line a little below the place, I entertain

scarcely any doubt that it is the same terrace with that here referred to.

## THE GREAT GLEN.

88. The Great Glen and its adjuncts present many objects of value in this investigation. The glen itself, as is well known, intersects the Highlands in an almost straight line, passing from south-west to north-east, terminating on the west coast at the inlet called Loch Linnhe, and on the east in the Beauly Firth—a line so straight that only four miles are lost by circumflex in sixty-two miles of space. Inclosed from end to end between two wall-like ranges of hills, only a mile or two apart, it is occupied for the most part by a succession of trough-like lakes, three in number—Lochy, Oich, and Ness—which are all of considerable depth, one of them profoundly so—Loch Ness being at one place 774 feet deep—in which respect they are known to exceed any part of the German Ocean. Their separations from each other, and from the sea, consist for the most part of low isthmuses of gravel, through which passages have been cut to form the whole into a canal; 22 miles of cutting to 40 miles of lakes.

89. A groove in the structure of the country, so peculiar in its straightness, narrowness, and depth, may well be accounted a singular phenomenon. I

am, however, concerned only with the isthmuses which hold in the lakes, and with the other alluvial matters pertaining to the district. Those at Inverness are very interesting.

90. Mr George Anderson, an able geologist residing at Inverness, was the first to point attention to a remarkable gravel terrace which extends for about a mile and a half behind that town, and which is ascertained * to be 96 feet above the sea at its frontier, rising from thence to 117 in its inland parts. The castle of Inverness, and the ancient building which is supposed to have been Macbeth's residence, were situated on promontories of this terrace, looking over the Beauly Firth. The town, originally seated on it also, but now chiefly placed on a lower alluvium nearer the river, still occupies a portion of the escarpment of the terrace under the castle. Far, however, from being confined to this place, it extends along the Beauly and Moray firths for many miles on both sides, likewise up the right bank of the Ness. Standing on any prominent situation at the town, and looking eastward, we see it advancing in a flat line from the hills, and then stooping, like the sweep of a lady's train, to the low plain near the sea. Passing along the road from Inverness to Fort Augustus, we find it rising wall-like to the

* By measurements obligingly taken for me by Mr George G. Mackay, of the Observatory, Inverness.

left. Mr Anderson has remarked that it corresponds with the summit-level of the glen at Laggan between the lakes Oich and Lochy. This, it will be remembered, is in accordance with what has already been spoken of as a common case—alluvial terraces coinciding in elevation with land-straits or passages amongst hills. The same terrace appears likewise, though less conspicuously, at the south-west extremity of the glen, a little beyond Fort William. In leaving that town by the road to Ballachulish, we have it hanging over us to the left, exactly as in leaving Inverness by the road to Fort Augustus. Its identity, in point of form and elevation, with the terrace described at Perth, and others throughout the country, may be regarded as one of the most remarkable facts connected with the present subject.

91. Let us now consider one of the isthmuses. Loch Ness, 45 feet above the sea, is divided from Loch Oich, 94 feet, by one of three or four miles extent, which is chiefly a mass of gravel, there being only a few masses of rock here and there projecting through. At its northern extremity, at Fort Augustus, we speedily discover that it is marked by various traces of ancient sea-levels. Near where the Tarf pours into Loch Ness, there is a distinct terrace, about 59 feet above the lake, and which appears likewise near the village and on the banks of the canal. This of course ($45 + 59 = 104$ feet) is the same marking as the Inverness terrace. Higher

up, and towards the opening of the Tarf glen, we see a second terrace of small extent; also a more conspicuous third one, forming a strong projection from the hill-side, and corresponding with a *bench* on the other side of the river, on which Abertarf House is situated. This last terrace—called Tom-voit (the hill of the court), because justice was dispensed upon it in ancient times—is about 377 feet above the sea. Higher still, on the face of the hill above the opening of the glen, we see short straight lines slightly inclined up to the opening, and which appear as the vanishing traces of more ancient alluvia: the most decided is 530 feet. The whole matter is of little consequence, except for showing that the isthmus is connected essentially with this river. Now, the fact which we desire to see accounted for is the locality of these isthmuses—how it comes that one exists here, for instance, between two deep lakes—a position which puts currents of the ancient sea, debacles, and all such phenomena, out of the question. A previous study of streamlets and their deltas suggests an answer to the question, which can only require the verification of other observers in order to be satisfactory. An isthmus, in such circumstances, is the creation of one or more rills from the side-glens. In this case, it is the Tarf at the north end and the Chalder at the other, which, by their united spoils surrendered to the ancient sea, produced the effect. If we carefully examine the Great Glen, we shall see

that *all the side-glens containing mountain rills of rapid descent, and consequent great power of bringing down debris, occur at the isthmuses.* The hills bordering the lakes are for the most part an unbroken wall. One or two large openings, as those of the Urquhart and Garry, are indeed presented to loch sides; but in the one case, there is a river of gentle descent passing through a wide valley—in the other, a water newly come from a lake of its own, so as to have had little alluvium to bring. These rivers, in short, do not answer the requirements of the case as to detrital power. It is rivers of no great account in maps—brief pithy mountain-burns, almost nameless except to simple swains—which do most of this work. Such appears to have been, in a class of cases, the *origin of lakes.*

92. The isthmus between Loch Ness and the Beauly Firth has in this manner been formed by the comparatively obscure streams which descend from the hills behind Dochfour, near the lower end of the lake.* It has been at one time a mass filling up the valley to the depth of between 200 and 300 feet:

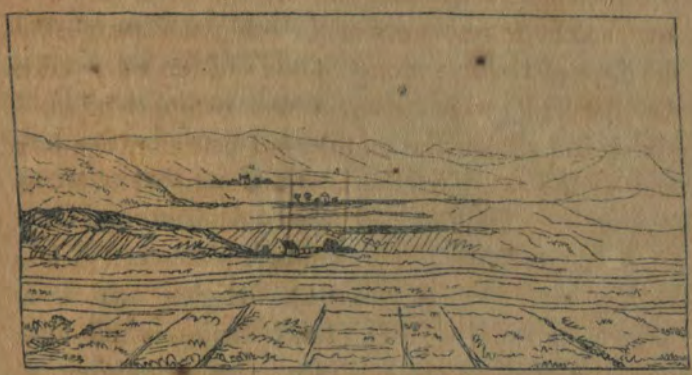
* One of these rills comes down from the hills at a place called Dochnacraig. The prominent hill-face to the north of this tumbling streamlet is rudely terraced, partly perhaps, if not wholly, from depositions of detritus when the sea was at higher levels. The upper parts of the markings are, respectively, about 205, 344, 461, 562, and 626 feet. From the flat at 461, the level takes up another near the Erchet wood on the opposite side of Loch Ness. A similar flat is taken up on the same side, near Aldourie, from the 562-feet level.

since then, a trench has been cut through it, in the bottom of which the river pursues an equable course between the lake and the sea. We still, however, see huge remnants of the original mass, both in the form of terraces along the side of the vale, and in the Tor Hill, which rises, a vast compost of sand, gravel, and silt, in the middle, but nearer to the lake than to the sea. In the accompanying sketch, the

ANCIENT ALLUVIUM AT BORLUM, INVERNESS-SHIRE.

passage of the river between a terrace of 165 feet at Borlum House on the one hand, and Tor Hill on the other, is given as it appears from a spot three miles south-west of Inverness. The gentle declivity of the Tor Hill towards the lower part of the valley is a *stair* of terraces—a most striking memorial of the work of the sea as it declined away from the ground. In the following sketch, they are presented as seen from the lawn in front of Laggan cottage, but with less firmness than belongs to them. The river and canal are

seen below; one of the masses of the Tor Hill to the left, with a group of cottages called Milton at its



TERRACES AT DUNNAIN.

base. Above this is a terrace at 121 feet above the sea: at its northern extremity, and divided from it by a low furzy ridge, is one 10 or 11 feet lower, where the level takes up the plateau behind Inverness. After passing faintly-marked terraces on the slope above, 165 and 189 feet, the former being on a level with the flat at Borlum, we come to a long plain over which proceeds the road from Inverness to Skye, and which is distinguished by a large suite of modern farm-offices, as faintly indicated in the sketch. At its lower extremity, it abuts on Tor Vane. Its length being the true seaward line, we are not to be surprised by finding it slope up from that hill towards Tor Hill, against which it abuts at the other extremity. A professional survey gives

SECTION OF TERRACES AT BORLUM AND DUNNAIN.

the height at three several points on this long slope as 193.7, 217.3 (this at the farm-offices), and 223.6; so that it stands in the same light with regard to the history of its formation as the St Andrews and Carnoustie plateaux (§§ 36, 64). Higher still is a third distinguished terrace, also presenting a seaward slope. This, at Dunnain House, seen in the sketch, is 279.5 feet; it rises a little towards the left.

93. Perhaps, however, the most interesting relics of this isthmus are the hills of Tor a'Bhean (pronounced Tor-Vane), and Tom-na-heurich, opposite to Inverness; the first a promontory starting out from the side of the valley, the latter an isolated mount at the outer extremity of the

other. The steep sides, flat tops, and gravelly consistence of these eminences, have made them at all times objects of local interest. The common people have their own mythic accounts of their origin, and imagine them as favourite haunts of the fairies. In our investigation, they take their place simply as remnants of an alluvial sheet once more widely spread. Tom-na-heurich, being 206 feet high, probably has belonged to a plateau of about that height, of which other examples are found in this region of Scotland, and elsewhere. Amongst the gravel composing it, which contains pieces of all sizes under a man's head, Mr Anderson has detected some far-transported rocks, and some of a reddish small-grained granite which occurs *in situ* near the mouth of one of the burn-glens at Dochfour, here set down as the birthplace of the whole of the Ness isthmus.

94. As the summit level of the Great Glen is only about 100 feet, it follows that, when the sea rested on the Inverness terrace, this grand trough was filled by a sound, rendering the north of Scotland an island. Some of the memorials of the higher levels of this sea have already been spoken of. A whole range of them may be seen in the side valley of Urquhart.* Mr Milne also states that he has found terraces at 213 feet above the sea on the side of Loch

* The most remarkable one is behind Balmacoin mansion-house, 277 feet above the sea.

Lochy. On the face of the hill, nearly opposite to the opening of the Urquhart vale, there is a remark-

TERRACE AT ERCHET, ABOVE LOCH NESS.

ably fine example of the long flat line occasioned by the terrace-like meeting of the cultivable ground with the bare sterile rock above; the farmsteads of Erchet and Drummond seated on the top of the good ground. This is 497 feet above the sea, the elevation of one of the terraces in the southern part of Scotland. Generally along the Great Glen, the hill-faces present few markings of the nature of terraces. On the west side all is rough and rocky; on the east, the equally steep but less rough braes are masked with a thick peel of alluvial matter, only seamed vertically by the descending torrents. At one place, nevertheless, on the rough side, in the hollow of a mountain called Cairn Scourach, there are two or three horizontal lines faintly inscribed on the faces of the steeps, somewhat like those in Glen

Roy—visitable, however, I fear, by none but the mountain roe and the eagle. We shall also have occasion to refer in the sequel to a very lofty marking in a side-valley near Laggan.

## LOCHABER.

95. The reader is now requested to transfer his thoughts to the west side of the island; for, henceforth, for some time, we speak of lands which decline and streams which flow towards the Atlantic. We start at the southern extremity of the district of Lochaber, where the deep inlet of Loch Linnhe sends off a branch called Loch Leven to penetrate far up into the alpine regions of Glenco.

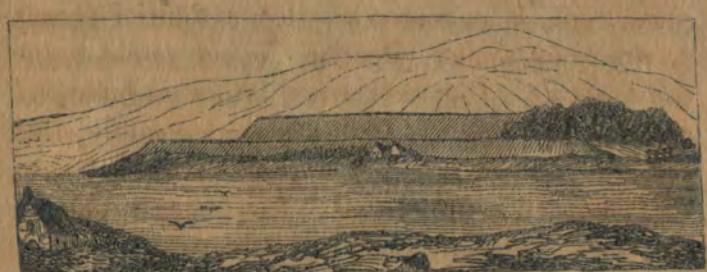
96. Loch Leven, when examined at Ballachulish and its neighbourhood, is found to be contracted in various places by low promontories starting out from the base of the steep hill-sides, perfectly flat in the surface, and composed of gravel, in some places resting on rock. At Ballachulish there is such a promontory on each side of the water, contracting the loch to about 150 yards width, and forming the well-known ferry at that place (§ 10.) All of these promontories are about one height, 42 to 44 feet, and have obviously been shaped by some common agent. A few hundred yards back from the flat at the inn on the south side, another terrace

may be traced amidst the pleasure-grounds of Ballachulish House; it is about 65 feet above the sea.

97. It has been said that some of these promontories rest on solid matter. That just mentioned forms the mere covering of a table of rock, the verge of which is seen shelving down to the sea-side at the ferry. The seaward face of this rock, from the place where it comes out from below the gravel coverlet down to the place where it dips under the water at low tide, is smoothed as by some mechanical agency, so that no prominence is left above a certain general facing, and no place is rough except where this facing has been broken off. The smoothing has a horizontal tendency; it passes through inclosed pebbles and crystals; but, when inspected with some little care, we find that it is everywhere seamed or scratched in the same direction. That these appearances, which are not uncommon in Scotland, resemble those left by the glaciers of the Alps upon the sides of the valleys and gorges through which they pass, is, I believe, generally admitted; at the same time, it is contended that a diluvial agency working in similar situations would produce the same effects. I do not enter into this question; but, whatever was the agency, it is abundantly clear that it belonged to a period prior to that which I am concerned in illustrating. The flat gravel plains lie quietly over these smoothed surfaces, as the memorial of a state of things which could not have

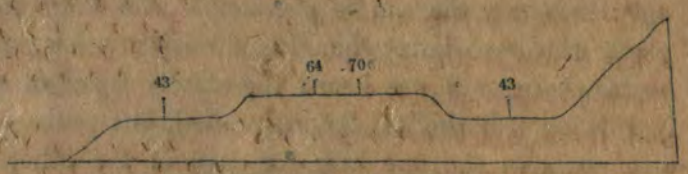
come into existence till the causes which produced the smoothing had ceased to operate. The gravel comes near the close of an immense series of transactions in which water was chiefly, if not solely, concerned, and which would appear to have mainly been posterior to any trace of this kind of action. It is as if we were to find a little garden blooming in the midst of some ruined Norman keep. We know that those rough walls had long served their purpose as a defence in the middle ages. They passed into neglect, and finally into ruin, some centuries ago: it is only the simple old couple who show the place, who have lately thought of raising a few pot herbs where once was heard the stately tread of a Neville or a Berkely. So intervalled, but perhaps with years in the one case for days in the other, stand the gravels and the rock-smoothings of Ballachulish.

98. Between Glen Rie (§ 10) and Fort William, terraces appear at little intervals along both sides of



TERRACES AT CONNEL FERRY.

Loch Linnhe. The aspect of a gravel promontory starting from the Ardgour heights at Connel Ferry is very remarkable, presenting two sea-marks at 43 and 64–70 feet with the greatest distinctness; the same terraces, moreover, being presented on the other side of the strait. A sketch of this Ardgour promontory is given; but it is worthy of remark that the 64–70-feet elevation does not extend the whole way back to the hills—there is an interval at the 43-feet elevation, so that a section of the whole assumes the following form:—




SECTION OF TERRACES AT CONNEL FERRY.

99. Within a mile of Fort William, terraces become very conspicuous on the croft-patched hill under which the town is situated. Ascending at Mile-Craig House, we find the slope presenting the following appearances at the various heights indicated by the figures. On the line of a mountain-road which ascends from the west end of the town towards Glen Tarbert, these markings are seen very distinctly, besides a few more at the following elevations—144, 202–13, 288, 325. [See woodcut on next page.]

It will be observed that all of these Lochaber terraces bear a rough correspondence in elevation with

others already presented to our notice.

100. We have now returned to the Great Glen, but only to advert to a strath connected with it. If we stand at the western extremity of this glen, any where between Loch Lochy and Fort William, and look directly eastwards, we have before us the opening of Glen Spean, with the Ben Nevis heights on the right, and those which overhang Loch Lochy on the left, the wide space between being, however, not altogether a valley, but a tract of low heights, with hollows between, through one of which the Spean descends to join the Lochy. The chief of the low heights is Tom-na-Pearchan; a somewhat lower one to the westward, called Unichan, is 642 feet, being for the most part a mere mass of gravel. It was between Unichan and the Ben Nevis heights that Montrose debouched with his Highland bands, when

SECTION OF TERRACES NEAR FORT WILLIAM.

about to stoop down on the unfortunate Campbells at Inverlochy, in 1645. On many parts of these intervening heights, terraces mark ancient levels of the sea. If, for example, we pass up the Spean, from Maucomer, where it joins the Lochy (see map), we find first a flat, on which the hamlet is placed, 141 feet above the sea-level; next two slopes in the ancient delta of the river, running up respectively to 167 and 210 feet. Thereafter, we come to a great flat-topped projection on the side of Tom-na-Pearchan, overhanging the river, and having a hamlet called Brecklech seated under it: this is 391 feet. Two or three miles up the glen, standing at the Bridge of Spean and looking around, we see terraces everywhere — on Tom-na-Pearchan, on Unichan hill, and along the sides of Glen Spean itself. One of those on Tom-na-Pearchan is a continuation of the flat at Brecklech. Others are lower. Along the north side of Glen Spean, for a couple of miles at least, a conspicuous terrace is presented, from 40 to upwards of 100 feet above the road, according as the latter rises and falls. Kilmanivaig church and manse, and the mansion-house of Tiendrish, are situated upon it. Composed of a mass of pure sand and gravel, and perfectly level, it is 325 feet above the sea. By-and-by, as we advance to the Bridge of Roy, we see other terraces on both sides of the river—broad flat masses abutting against the hill-sides, always broadest at the openings of side-glens,

where, as usual, a rill skirts or intersects them on its way from the parent hills. One of these, having a strikingly flat outline, and bearing the farmsteading of Corryhoilach, is about 348 feet above the sea. It is probably the same sea-marking with one found in the valley of the Tweed and other places. Immediately to the east of it, above the house of Inch, is another equally well-defined terrace, 364 feet—an elevation which as yet stands singular in our researches.

101. We are now entering upon a district which presents markings the most remarkable of this kind in our country, the region of what have been called the PARALLEL ROADS of Lochaber. The reader, if he refers to the accompanying map, will be at no loss to understand the relations of places to each other in this district. He will trace Glen Spean in an easterly direction from the Lochy to its proper termination at Muckull beyond Loch Laggan, where a *land-strait* connects it with a branch of Strathspey. He will find Glen Roy branching off from Glen Spean, towards the north, but finally turning eastward, and terminating in a similar connexion with the head of Strathspey, but at a greater elevation above the sea.

102. On advancing a mile or two from the Bridge of Spean, the first distinct glimpse is caught of one of the *Roads*. Far above the terrace lately spoken of, and the gravelly slopes which rise still higher,

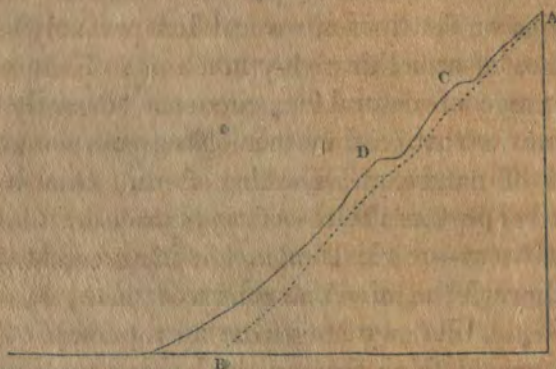
a line is seen extending along the face of the steep heathy or grassy hills, both on the side of the vale by which the road passes, and on the opposite side several miles off. This is the lowest of the *Roads*, and it extends for miles with little interruption along the glen, ceasing only a few miles short of Loch Laggan. It is readily seen to be a different marking from the terraces belonging to the same district, in as far as it has no projecting gravelly mass to rest upon, but is merely an indentation in the soft matter which forms the mask of the hills. Its remoteness and elevation also create a feeling of novelty. The single line in Glen Spean usually produces little impression on the beholder, though there is certainly something arresting in the appearance of such a belt filleting the huge green masses on the far side of the glen. When we turn, however, into Glen Roy, and, wheeling round a shoulder of the hill near Achna-

GLEN ROY, NEAR ACHNAVADDY.

vaddy farm-house, come into view of *three lines* all equally or more distinct, passing along the faces of the hills on both sides, we feel that we are in the presence of something very much out of the common range of natural appearances. It strikes us as some vast artificial work mingling with the grand scenes of nature, and rivalling them. One is reminded of Jupiter's belts—of copy lines ruled for text and half-text—so whimsical are the images which may rush through the mind on such an occasion; or, musing a little, till fancy has stolen upon perception, we may come to think that we are looking up through an aqueous medium at the markings which it makes where it lips the upper ground. For five or six miles, these three lines pass along both sides of Glen Roy with scarcely any interruption, everywhere forming a sort of level pathway; so that it is not surprising that the common people should have believed them to be roads which had been made for the convenience of Fion and his heroes in hunting.

103. The hills of this district, composed of clay-slate, mica-slate, and granite, and ascending in general to from 2000 to 3000 feet above the level of the sea, are covered along their sides with soft matter composed of clay and sharp stones, apparently a debris of the hills themselves, formed in water. A close examination of the shelves, as they may properly be called, shows them to be impressions on this alluvial coating, after the fashion of the follow-

ing section, borrowed from Dr Macculloch and Mr




A, B, supposed original surface of rock.
C, D, shelves in the outer coating of the hill.

Darwin. They vary from a few feet to 30 in breadth, but rarely are flat in that direction. Almost invariably, they form a slope, declining, as in the section, away from the hill-side. The accompanying sketch,

No. 4 TERRACE AT OPENING OF GLEN GLASTER.

however, represents one place, where there is both a considerable breadth and a remarkable degree of flatness. The lines are everywhere perfectly horizontal and parallel to each other, and in each case the line on one side of a glen corresponds exactly in elevation to that on the other. These are points which a skilful engineer has settled after all requisite care, not to speak of the observations made with less perfect means by Sir Thomas Dick Lauder, Mr Milne, and myself, all of which conduced to the same conclusion. Were water again to fill these vales, its surface would to a certainty be parallel in its line of convexity with the terraces.

104. Previous writers enumerate only four proper and distinct terraces as belonging to this district. One higher than the other three appears in a narrow vale called Glen Gluoy, which does not belong to the Spean collection of waters, but opens on the side of Loch Lochy, having only its head towards Glen Roy. The Glen Gluoy shelf has been recognised as No. 1, while those of Glen Roy have been named in descending series as Nos. 2, 3, and 4, the last alone being held as common to Glen Spean. According to a levelling survey executed for the first time at my request,* the lowest or No. 4 shelf is 758′ 2″

* By Mr William Paterson, under the directions of Joseph Mitchell, Esq., civil engineer, Inverness, whose conduct throughout my inquiries has been most obliging.

above Loch Lochy, when the waters of that lake stand 21′ 3″ on the lock gate at Laggan; which may be regarded as equivalent to 847 feet above the sea at Inverness. The No. 3 shelf was found, by the careful survey of Mr David Stevenson, to be 212.37 feet above the 4th; while the 2d was 80.32 higher than the 3d.* The Glen Gluoy shelf has by levelling been twice set down as 20 feet above the No. 2 shelf in Glen Roy. Mr Milne and I, though using means not calculated to ensure great accuracy, felt assured that it was not under 29 feet, while I made it "fully 30." There is still another vale in this district marked with a shelf: it opens on the Great Glen at Laggan, and approaches at its upper extremity to the head of a branch of Glen Roy. The name given to it in Thomson's Atlas is Corry Alt dhu na Laggan. Mr Darwin, who discovered this terrace, describes it as appearing by barometrical measurement at 1120 feet above Loch Lochy.† It is interesting as showing a third in addition to two other terraced valleys, all branching from one common high ground. As will be observed in the map, there is only a limited

* Mr Stevenson's MS. A barometrical measurement by Dr Macculloch gave the upper line in Glen Roy as 1266 feet above the German Ocean.

† Mr Darwin considers this the same as 1202 feet above the sea, judging Loch Lochy to be 82 feet above that level. The loch having for some years been a few feet higher, in consequence of improvements in the Canal navigation, there may be a slight under-statement here.

central portion of the length of Glen Roy, in which its three shelves are to be seen. The lowest is lost in the ascent of the glen towards the head, and only the two upper enter into the two high glens into which Glen Roy may be said to branch. In the other direction, No. 2 vanishes on the east side of Glen Roy, just before 3 and 4 enter a side-vale called Glen Glaster, soon after emerging from which No. 3 vanishes also. Opposite to this point, the isolated hill of Bohuntine, having a valley circling round behind it, bears all three on its north-east point, but on the other side, exhibits only No. 4, which continues thence into Glen Spean. There is also an isolated and comparatively low hill called Mealderry, near the mouth of Glen Roy, which is marked round its top with the No. 4 shelf.

105. It is remarkable of these terraces, that each of them comes, at some portion of what may be called its course, to a *col* or passage between the heads of glens. No. 1 runs on precisely the level of the passage connecting its own glen (Glen Gluoy) with the Turit branch of Glen Roy. No. 2, sweeping far up the other branch of Glen Roy, stops only about 8 feet above the opening into the head of Strathspey. No. 3 coincides in the same manner (a fact ascertained by Mr Milne) with the head of Glen Glaster, a branch of Glen Roy. For No. 4 there is a coincident passage from Glen Collarig (a branch of Glen Roy behind Bohuntine Hill) into

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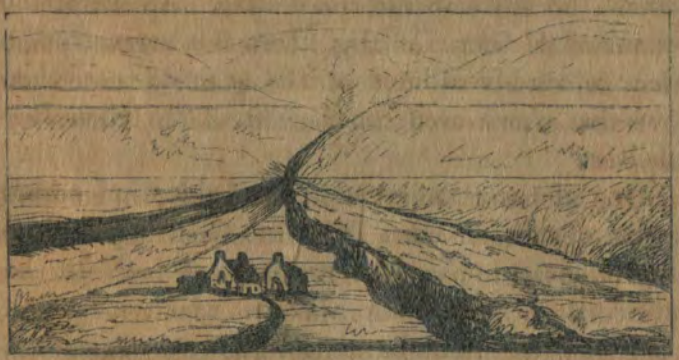
Glen Spean, and also the pass of Muckull, already alluded to as the opening between Glen Spean and a branch of Strathspey. The map is made to express the most of these facts by arrows pointing in each case out of the glen in which the terrace is expressed, to that in which it does not appear.

106. Some other circumstances, though of a minute nature, are not without their value. The terraces are observed to intermit wherever rock projects from the hill-face, and where cuts have been made in the soft facing of the hills by torrents. In some of the latter, however, the horizontal line bends round and goes into the recess as far as there is soft ground. There is a conspicuous corry on the east side of Glen Roy, opposite Achnavaddy farmhouse. It seems to have been produced by a land-slip, for just below there is such a protuberance as would be made by the lapsed matter—a clear and distinct projection from the general outline of the glen. Now the two highest shelves pass through the corry and are lost in its recesses; while the lowest is slightly marked on the protuberant matter below; clearly showing that the land-slip was an event anterior to the cessation of the cause by which the shelves were produced.

107. At the openings of all side-glens into Glen Roy, there are remnants of the ancient *deltas* of the tributary streams, and some of these are connected

in an interesting manner with the shelves. At Branachan, for example, on the east side of Glen



DELTA OF A RIVULET AT BRANACHAN, GLEN ROY.

Roy, near the shooting-lodge of Dalreoch, we find a delta, cut down as usual by the burn into several different levels, but *leaving the apex very nearly adjoining to the No. 4 shelf.* At Corry-na-rionach, a place near by, the stream, instead of cutting the delta into two wings, leaves the mass entire, and passes it at one side; in this case, the apex reaches up to nearly the No. 3 shelf. The difference between these two side glens is, that the former recedes for a considerable way at a level little above the No. 4 shelf, while the other is a short high glen having its opening into Glen Roy at a point nearly as high as the No. 3 shelf. In the latter case, supposing water to stand at the No. 3 shelf, the burn would have no resting-place for its spoils before coming into Glen Roy; in the other case, the burn

would have such a resting-place in its own glen, and would only deliver matter in Glen Roy, when the water had fallen to the No. 4 shelf. At one of the openings of Glen Collarig, there is a remnant of a delta which Mr Milne describes as rising more than 100 feet above even the highest of the Glen Roy shelves.

One of the grandest objects of this kind occurs at the opening of Glen Turit into Glen Roy. Here vast truncated masses of gravel start out into the principal glen, forming a scene which may well surprise even those who are not wholly unacquainted with the alluvial phenomena of the Highlands. Another is presented at Inverlaire in Glen Spean. This may be described as a series of gravel plateaux, fully a mile in extent, some of the masses abutting against the hill-sides, others standing out partially isolated, one of the latter being gathered round a

ALLUVIAL PLATEAUX AT INVERLAIRE, GLEN SPEAN.

small hill of somewhat greater height called Tomna-fersit. In the centre of the preceding sketch, this eminence appears, surrounded by its alluvial circlet; to the left is the opening of Loch Terig; to the right, the glen of the Laire Burn, both flanked by terraces of this matter. All these masses are truncated by a plane which can easily be connected into a slope of very small inclination, the upper part of which points to the Laire Glen, and comes precisely to the elevation of the No. 4 shelf. This is a peculiarity which I detected by careful levelling, and it serves to complete the explanation of the origin of what has hitherto appeared a very anomalous object. When the valley was filled with water to the height of the No. 4 shelf, the Laire formed an extensive gravel deposit around its embouchure, the outer edges declining slightly below the surface. The water, on sinking to a lower level, beat upon the outer edges of the mass, which it cut down into steep cliffs; the Laire, as has been usual in such cases, carved a channel for itself through the mass. But another event, less common, took place. The delta of the Laire, extending a good way to the right, lay across the mouth of a long hollow in the original rock formation, the bed of the present Loch Terig. The fresh-water lake left in this hollow on the recession of the waters, was held in at its lower end for at least 100 feet of its depth by the Laire alluvium. The water issuing therefrom,

in connexion perhaps with the action of the sea beating at a lower level outside, cut out a channel fully 100 feet deep, forming another great intersection of the Laire delta. We see the remnants of this blockage to this day resting on the sides of the narrow passage into Loch Terig, but not exactly to an equal height, for that most remote from the Laire Glen is in a small degree the lowest. Even now, the existence of Loch Terig may be said to be partly owing to the ancient doings of the Laire, for the gravelly bed of its stream shows that the blockage is not cut down so deeply as it might be.

108. But by far the grandest delta of the district is that hill which has been referred to under the name of Unichan, as occupying so much of the mouth or lower part of Glen Spean. This is a mass of gravel, eleven miles long by perhaps two broad, and reaching an elevation of 612 feet. I observed rock rising through it at one place; but it is mainly, as has been said, a hill of gravel. No one uninstructed as to the works of streamlets in an alpine country subject to a moist climate, could imagine the actual origin of this hill. On the contrary, no one who has studied this subject, who has passed from such deltas as those in Glen Dochart to such as that at Inverlaire, and everywhere found them in connexion with mountain streamlets, can be at a loss to pronounce Unichan as composed of the united

spoils of certain burns descending from the vast mass of mountains adjoining to Ben Nevis on the east, and facing here towards the Spean. When the sea stood at a level somewhat above 622 feet (and there is evidence of its having paused long at 628 or 630), these burns delivered their spoils in the estuary filling Glen Spean. On its withdrawal, this mass was left. The Spean then assumed a passage between the outer skirts of the mass and the opposite hills. These are, in their way, grand natural transactions, and they derive additional interest from a consideration of the apparent minuteness of the cause.

109. Viewing the singular appearance of the Glen Roy terraces, and the narrow local bounds to which, in their most palpable form, they are confined, it is not surprising that they should have given rise to many contending theories. Pennant thought it not unlikely that the country people were right in representing them as roads for the Fingallian heroes. So lately as 1816, Mr Playfair sent a letter to the Royal Society of Edinburgh, setting them down as aqueducts for artificial irrigation, like those he had seen in the Valais near Brieg. The first attempt to explain their origin in the spirit of modern geology was by Dr Macculloch, who endeavoured to show that they were produced by fresh-water lakes, once confined in the valleys to the height of the various terraces. This view was further elaborated in a very able paper by Sir Thomas Dick Lauder. It

required the assumption of the former existence of a barrier across the western extremities of the glens, causing the supposed lakes to discharge their surplus waters in the contrary direction. Thus it was thought that the waters of *Loch* Gluoy flowed over the present head of that glen into *Loch* Roy. *Loch* Roy at the same time discharged itself into the head of Strathspey. Afterwards, the barrier of *Loch* Roy falling a certain height, a lower outlet was found. At length the special retention of *Loch* Roy failing altogether, it became part of a lower lake filling Glen Spean, and which overflowed at the pass of Muckull. The great objection to this hypothesis was the difficulty of supposing any such barrier. What did it consist of? How came it there? How did it recede, first, from a point above Glen Collarig, where shelf 2 ends; second, to a point a little farther down, where shelf 3 ends; and, finally, to the lower part of the Spean valley? Some years afterwards, Mr Darwin came fresh from the mobile continent of South America, and pronounced these vales to have once been filled with arms of the sea, and the shelves to be the memorials of the pauses made by the land in its process of upheaval. The greatest difficulty in the way of this theory is the definite locality of the objects. It could not well be supposed that the upheaval was confined to one small group of glens—why, then, are the shelves so limited in their range? Why, moreover, is the Glen Gluoy terrace not ex-

pressed in Glen Roy? Why are the Glen Roy ones not apparent in Glen Gluoy? And why is only one of the Glen Roy trio extended into Glen Spean? Had the perfect horizontality of the shelves then been admitted (which it was not, notwithstanding the strong testimony borne to this fact by Sir Thomas Dick Lauder), the hypothesis of an upheaval in any degree local would have been felt as attended by a still greater difficulty. At that time, however, the mobility of the land was an ascendant idea, and hence Mr Darwin's views regarding Glen Roy met with general favour. They did not, nevertheless, prevent a new theory from being soon after started by M. Agassiz and Dr Buckland, who made a tour in Scotland in 1840, for the purpose of inquiring if any traces of ancient glaciers existed in that country. They everywhere beheld in terraces and deltas of streamlets the work of those favourite agents; to which extent their belief was participated by Mr Lyell in an investigation confined to Forfarshire. M. Agassiz published in 1842 a paper, expressing his own opinion and that of Dr Buckland, that glaciers were the cause of the Parallel Roads of Lochaber. They imagined that a glacier, issuing from one of the side glens near Ben Nevis, had passed across Glen Spean, so as to form a barrier for a supposed lake in that quarter, while a similar barrier was formed by another glacier issuing from the hollow now filled with Loch Terig. By these means a portion of Glen

Spean, being that part with which Glen Roy is connected, was shut up as a lake to the height of the highest Glen Roy shelf. The ice-barrier at Loch Terig giving way piece-meal, this lake sunk at two stages, till it was confined in that direction by the summit-level of Muckull. Thus all the exigencies of the phenomenon were held as satisfied. Certain polishings in the gorge of Loch Terig, and on the exposed rocks on the opposite side of Glen Spean, appeared as clear proofs of the existence of at least one of the glaciers. M. Agassiz also declared the flat-topped gravel masses at Inverlaire precisely to resemble the numerous moraines of the neighbourhood of Tines in the valley of Chamounix. There are several fatal objections to this hypothesis; one, making all others superfluous, is, that it does not take into account (what indeed was not then known) an opening at the head of Glen Glaster, by which all water, above the No. 3 shelf must have been discharged. Another is, that the No. 4 shelf passes far to the westward, beyond the supposed icy barrier in that direction.*

110. The theory of Mr Darwin at length met a

* See Milne on the Parallel Roads of Lochaber, p. 16. Mr Milne describes smoothed rock-surfaces as observable in various parts of the shelf district, particularly on the right side of the gorge of Loch Terig, to the height of about 786 feet above the lake. He could not find any, where M. Agassiz found them, in the bottom of the Spean valley at the outlet of Loch Terig. Those on the opposite side of that valley are very striking; they are somewhat above the level of the No. 4 shelf.

formidable challenge from Mr David Milne, who has paid two visits to the district, and examined it with that care which alone can entitle any one to speak on a subject invested with such difficulties. Though originally impressed in favour of the marine theory, Mr Milne ultimately saw reasons for returning to that of Macculloch and Lauder; and he has stated these with a candour only equalled by the industry he has shown in the collection of facts. One piece of evidence on which he chiefly builds, and which he himself was the means of completing, must be admitted to be of a very striking nature—namely, that, as already said, there is a *col* or head of a glen, of coincident elevation with every terrace, as if forming the ancient outlets of the lakes towards the west. Mr Milne further observes that, in the passage from Glen Gluoy into Glen Turit, and in that from Glen Glaster into Glen Spean, there are appearances as of the former passage of a much

PASS OF MUCKULL.

greater volume of waters than the little rills which now flow there. So also the Pass of Muckull, the supposed outlet of the lake of the No. 4 shelf, presents the appearance of an ancient river-course, a flat passage of 70 feet wide, confined by wall-like rocks which seem water-worn. With regard to the difficulty of the barrier, he thinks that, in the first place, it would not require to be so lofty as has been supposed, seeing that the height of the bottom of the valleys has not hitherto been taken into account. The recession from above to below the Collarig and Glaster openings, would, he thinks, be accomplished by *a scooping out of the inner part* by means of the rills descending from those side-glens. The final remains of the blockage he points out in the hills of Unichan and Tom-na-pearchan, which approach to the height of the lowest terrace. The supposed blockage of Glen Gluoy he presumes may have experienced a similar fate.

111. The weakest point in Mr Milne's arguments is as to the history of the blockages. Wherever we see rills at the present time falling into collections of water, whether sea or lake, they bring in fresh matter. None do they take away till the recipient mass of water has been withdrawn. If, moreover, the termination of any of the lines were the proper index to the termination of any of these alluvially confined lakes, we should expect to see some remnants of the blocking-matter left at those places—

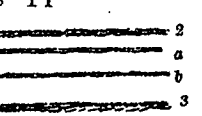
say, as hummocks on the sides of the vales, with only broken passages between, the phenomena of which we have examples on the flanks of the opening into Loch Terig. In reality, the lines vanish gradually on the smooth hill-sides, without any particular marks to distinguish the spot. Then as to what will generally be considered as the strongest of his arguments—the coincidence of the several terraces with heads of glens—its force is entirely taken away when we find that it is a common case. Instances will afterwards be adverted to in the Tweed vale, where no notion of confined fresh-water exists or could for a moment be maintained. Mr Darwin appears to have hit upon the proper explanation of this remarkable fact in physical geography. Regarding all these *cols* or land-straits as anciently sounds or channels between islands, he points out that there is a tendency in such sounds to be silted up, and always the more so in proportion to their narrowness. He has politely communicated to me a chart of part of the Falkland group of islands, prepared by Captain Sullivan, R.N., in which there are several examples of straits where the soundings are regularly diminished towards the narrowest part. One is so nearly dry, that it can be walked over at low water. In Weddel Island, again, there is a very low valley, terminating in shallow creeks, and which Captain Sullivan regards as a strait recently dried up in consequence of a

small shift in the relative level of sea and land. Straits hovering between the character of sea and land are familiar to ourselves: they are regarded by our Hebridians as fords. Such is the passage which (nominally) divides the islands of Lewis and Harris, and such is the division between North Uist and Benbecula, both of which would undoubtedly appear as *cols*, coincident with a terrace all round the islands, if the sea were to subside to any considerable depth.

112. The most recent theory of the shelves is that of Sir George S. Mackenzie, who suggests that they were made during the subsidence of a great and transient flood, their locality being confined to those regions where the water was comparatively free from agitation. It does not seem necessary, however, to enter minutely into the views taken by previous inquirers. The singular distinctness of the terraces in this district has induced observers too readily to imagine that such water-marks are confined to a particular region, and that special terraces are exclusive to particular parts of that region; while the fact is, that similar though fainter and less extended markings are traceable in other provinces,—and even in this district, the markings are in some instances protracted faintly beyond the limits within which their stronger impressions occur.

113. A fuller and more minute view of the district presents us in the first place with some subor-

dinate phenomena, which, though not unknown to former observers, have not been by them thought worthy of serious notice. I allude particularly to two shelves intermediate to Nos. 2 and 3, which appear at three several places in Glen Roy, namely, on the front of Tom-Brahn, which looks down the glen, on the face of Ben Ern, and on the hill opposite Achnavaddy farm. At the last place, under favouring light, I observed them with the greatest distinctness, presenting the following appearance:—




Mr Milne states the higher (*a*) to be 14 feet below the No. 2 shelf, and the other (*b*) to be 36 feet lower. In our conjoint examination of Glen Gluoy (Sept. 1846), we observed a second shelf below No. 1. It had been overlooked by both Dr Macculloch and Sir Thomas Dick Lauder. Seeing it perhaps in a more favourable light, Mr Milne and I entertained no doubt that it is a genuine shelf, of the same character with No. 1, and I find that Mr Easton, civil engineer, who some years ago examined this district with great care, sets it down also as a proper addition to the heretofore observed "Roads," though admitting, as we do, that it is considerably fainter. This line, which Mr Easton, in a communication of measurements with which he has favoured me, makes 200 feet below the No. 1 shelf, is traceable over several miles in the upper part of Glen Gluoy. Now, the existence of faint and

fragmentary shelves like these is valuable, as showing that *the water may have stood at certain elevations sufficiently long to make impressions in certain places, though not all along its margins.* Showing the possibility of failure in these hiatus, it shows that entire failures may have taken place—*that water, in short, may have stood at a certain point of elevation in the whole of these glens at once, but only left its mark in one, or in a part of one.* On this view alone, the supposing of barriers wherever any of the main shelves terminate becomes utterly inadmissible. The whole idea of the *locality* of the water which made the impressions may be said, indeed, to vanish; and it is seen that, to whatever cause the general conspicuousness of the terraces in Glen Roy is owing, whether to the character of the soft facing of the hills, to their steepness, or any thing else that is peculiar; it does not necessarily argue any particular and extraordinary history for this district.

114. It is now time to state that, in various portions of the shelf district, there are fragments of terraces not hitherto taken account of, some of which are similar in character to the intermediate shelves in Glen Roy, while others are a little different, but all of which are of material importance in any consideration of the case. Mr Milne and I observed them in several places in September 1846, but gave them no particular attention. At my second visit in the ensuing year, having by that time become

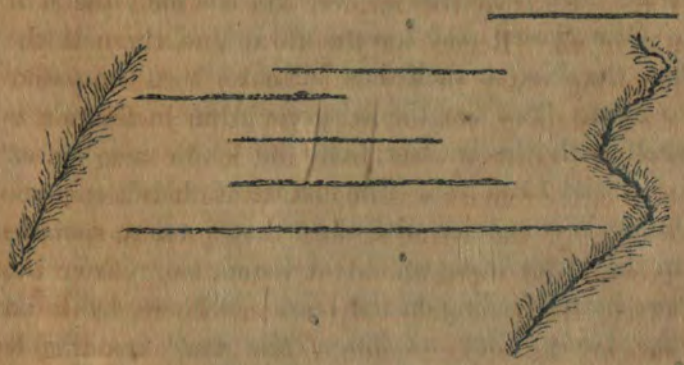
comparatively instructed in the investigation, I thought these appearances worthy of examination, and subjected them in some instances to the most careful measurement in my power. The additions thus made to the description of the district are very remarkable. Mr Milne, in his paper, speculates on a barrier in Glen Roy at the termination of the No. 3 shelf, conceiving that that shelf only ceased because the lower boundary of the lake represented by it terminated at that spot. Now I found a faint, yet still unmistakeable impression of the No. 3 shelf at a point *exterior to this spot in Glen Roy*, namely, above Bohinia village: the indentation is slight and extends no great way, but the level assured me that it corresponds precisely in elevation with a portion of the No. 3 shelf within sight upon the face of the hill of Crinachan. A small group of such markings is conspicuous on the face of Moel Dhu above Inverroy village, near the place where the No. 4 shelf terminates on that side of the valley. In

MARKINGS ABOVE INVERROY, GLEN SPEAN.

the subjoined sketch, the lowest line is the No. 4 shelf. The next, marked by the presence of a huge boulder fixed in the ground immediately below, appeared to me on a rough measurement, as 106 feet above the former, which would make it 953 in all. Regarding the third line, there is the following entry in my note-book: "A beach-like shelf; sloping, yet not at so rapid an inclination as the hill; covered with heath and long coarse grass." The latter remark was made because it is a common feature of the terraces, that they present spongier ground and more abundant vegetation. From this place, the level takes up a conspicuous bank-like line on the opposite side of the glen, extending on each side of the corry or gully above Inch House; described in my notes, as "equally good of its length as any piece of the No. 4 shelf marked below." Now these two markings, answering to each other across the valley, appeared from my measurements very little short of that interval above the No. 4 shelf, which brings us to No. 3, leaving little doubt that they do form fragmentary examples of that terrace, hitherto supposed to be confined to Glen Roy.

115. Farther up Glen Spean, at a point on the north side between Tulloch and Inverlaire, there is a group of markings precisely repetitive of that above Inverroy in point of level. But by far the most re-

markable assemblage of such markings occurs on the hollow face of Craig Dhu, on the north side of the glen, right above the falls of Monessie. These are all of them above the No. 4 shelf. The third from the



MARKINGS ON CRAIG DHU, GLEN SPEAN.

top, distinguished by a large quartz boulder reposing upon it, is bold and well defined. A terrace on the opposite hill-face, east of Loch Terig, corresponds with it in elevation, which the survey, exactly confirming my own rough measurements,* gives as 1290 feet above the level of the sea. Of the three lines below, I must have observed only

* The interval of vertical space between the gravel field over the Monessie chasm (§ 116) and the No. 4 shelf, is given in the levelling survey as 343 feet. My rough levelling, with a pocket-instrument fitted with a reflector, had made this 344 feet, being a difference of only one foot, or less than 4 inches on the 100 feet, which after all might be attributable to my fixing on a different point in the slope of the shelf.

two in ascending. They are noted by me as respectively 1055 and 1167 feet. In the first case, it will be observed, the elevation very nearly coincides with that of the No. 3 shelf. Thus, there appear to be *three fragments of that line on the right side of Glen Spean, and two on the left,* where nothing but the No. 4 shelf has hitherto been supposed to exist. Two lengthened protuberances above the shelf with the boulder, may be given roughly as 1337 and 1495 feet. The feature of abundant vegetation in connexion with the terraces was so decisive in the latter instance, that I found, to my surprise, two horses feeding on the spot. With regard to all the Craig Dhu markings, the most remarkable evidence for their being ancient sea-levels certainly is, there being fragments of shelves and other markings corresponding with each on the opposite side of the valley. First, a broad and somewhat hollow-faced hill called Ben Chlinaig, along which the No. 4 shelf passes with the distinctness of a sash round a lady's waist, bears farther up numerous horizontal lines, generally short and fragmentary, but often traceable as continuations of each other. Second, between this hill and Inverlaire is a high shallow glen, containing a rill called the Alt-na-Bruigh, along which there is a series of intersected deltas at various heights, *above* as well as below the No 4 shelf, and some of them corresponding with the Ben Chlinaig

lines. In no instance, when the level is directed across the glen from any of the Craig Dhu markings, does it fail to take up some strong line on Ben Chlinaig or some bisected delta winging the bed of the Alt-na-Bruigh. To the west of a burn which passes down Ben Chlinaig near Monessie, Mr Paterson found two lines, respectively 1260 and 1337, the latter being in correspondence with a line seen and roughly measured by myself. The two lines on the face of Ben Chlinaig corresponding to 1337 and 1495 are so bold, that I cannot but wonder at their not hitherto having attracted any special attention. I might make the same remark respecting the whole of these appearances, were it not that I may have been in no small degree indebted for my own detection of them to a forenoon of unusually bright sunshine. On the other hand, in most circumstances, the whole might appear doubtful to many persons; in an unfavourable light, a hasty observer might pass them by altogether unnoticed. Having now, however, traced such objects through all their gradations and connexions, from long lines to fragments, and from broad terraces to faint indentations, I should be left in no doubt of their character, even without the corroborative evidence of conforming levels. With that in addition to other proof, and with the decisive fact of the deltas of the Alt-na-Bruigh burn, *the existence of a body of water in Glen Spean at levels far above the*

*barriers assigned to it* by Macculloch, Lauder, and Milne, *seems to me established.* To go no higher than the delta-marking at the height of the No. 3 shelf, we see that this body of water, if of a lacustrine nature, must have required not merely a barrier at the west end of Glen Spean, but an additional one upwards of 200 feet high at the contrary extremity (the Pass of Muckull), which has never been pretended. It only remains that we contemplate the sea as the true cause of these markings, and if of those above the No. 4 shelf, it may be asked why not of that marking also, and all below?

116. It is of scarcely less importance to trace the marks of water-levels below the No. 4 shelf. We have seen terraces at 325 and 391 feet in the lower part of Glen Spean, besides many of inferior elevation. The 325-feet terrace, which extends so far along the right side of the valley, forming the site of Tiendrish House and the manse and kirk of Kilmanivaig, is repeated on the opposite side, on the frontier of Unichan; the modern farmsteading of Corryhoileach being situated upon it. A little farther up, Inch House stands upon a similar terrace, 345 feet. To return to the right side of the valley, a terrace of 283 feet appears between the road and the river, with a portion of the Inverroy hamlet seated on it. Passing into the opening of Glen Roy, we find the road mounting at the very first over a terrace, whose

long extending surface is 372 feet above the sea. It yields, however, in broadness and distinctness to one projecting from the skirts of Mealderry Hill, at the angle between Glen Roy and Glen Spean, bearing a hamlet called Achnaderry. This is 392 feet, correspondent of course with the mass at Brecklech. Farther up Glen Roy, the bottom of the valley is filled to a great height with these alluvial masses, insomuch as to have appeared to some as in no small degree diminishing the difficulty as to barriers in that glen. One, on the front of which Bohinia village is situated, is 520 feet above the sea. Returning to Glen Spean —In this valley, at Monessie, the river passes through a profound rocky chasm, forming a romantic piece of natural scenery. A little way down the glen, at the Catholic chapel, we see, on the opposite side of the river, a terrace which I learn, from the measurements of the survey, to be 428 feet. A little way onward, below Monessie village, there appears another at 446 feet. Next comes a flat gravel-field overlying a promontory of rock, round which the chasm pursues a curvilinear course: this is 504 feet, but its being a marking of the margin of the sea I consider as doubtful. On both sides of Glen Spean, at Monessie, we find huge protuberances of detrital matter starting out from the hills, and generally assuming in combination a rude terrace-like form, at 534, 627, and 734 feet. In the last case, on

Craig Dhu, exactly opposite to Monessie, there is a flat expanse large enough to make several fields. Besides all these objects, there is, above Monessie, a line of the true shelf character, below the No. 4 shelf; it appears from the survey at 661 feet, while a higher but fainter line is 750½. Along with these facts, let us keep in view that the No. 4 shelf itself (if not one of the higher) melts at more than one place into an alluvial plateau; while in Alt-na-Bruigh there are delta-markings above the lowest shelf. We consequently have, both as to the elevations and the form and consistence of the markings, an unbroken series from the present sea-level up to the highest of the *Roads*. The change from broad collections of alluvial matter to narrow shelves indented in the clayey facing of the hills, is not necessarily the mark of any change in the producing causes, as from a lake for the shelves to an estuary for the plateaux; it is merely that, in the descending course, we do not begin to have alluvia in the principal glens, till we get below the entrances of side rivulets into these glens. Connected as the markings thus are into one system, and being sure that both above and below the noted *Roads* a collection of water had operated, the evidence for those remarkable lines having been of marine, and not of lacustrine origin, appears to me to have now acquired a force scarcely resistible.

## Table of Terraces and other Markings in the Shelf District, Lochaber.

| | | |
|---|---|---|
| 1495 | Glen Spean, above Monessie; both sides of valley, . . . . | R. C. |
| 1337 | Do. do. do. | Survey. |
| 1290 | Do. do. do. | Survey. |
| 1261 | Do. do. Ben Chlinaig, | Survey. |
| 1159½ | Glen Gluoy, No. 1 shelf [1169 by R. C.], | Easton. |
| 1139½ | No. 2 shelf, Glen Roy, . . . | Survey. |
| 1125½ | Higher intermediate, at Achnavaddy, &c. | D. M. |
| 1089½ | Lower intermediate, . . | D. M. |
| 1059 | No. 3 shelf, Glen Roy; fragments in Glen Spean, | Survey. |
| 959½ | Lower Glen Gluoy shelf [969 ?] . | Easton. |
| 847 | No. 1 shelf, Glen Roy, Glen Spean, . | Survey. |
| 750½ | Faint line on Ben Chlinaig, . . | Survey. |
| 734 | Broad flat fields projecting from Craig Dhu, | R. C. |
| 703 | Delta-marking on Moel Dhu, above Inverroy, | R. C. |
| 679 | Lower and more distinct marking in same rill-course, . . . . | R. C. |
| 627 | On Craig Dhu, . . . . | R. C. |
| 534 | On Craig Dhu, . . . | R. C. |
| 520 | Terrace at Bohinia village, Glen Roy, | R. C. |
| 504 | Terrace above the chasm, Monessie, . | Survey. |
| 446 | Terrace below Monessie, . . | Survey. |
| 428 | Terrace opposite Catholic chapel, . | Survey. |
| 391 | Brecklech; Auchnaderry, . . | R. C. |
| 372 | Right side of opening into Glen Roy, . | R. C. |
| 345 | Terrace at Inch House, Glen Spean, | R. C. |
| 325 | Terrace along right side of Glen Spean; Tiendrish, Kilmanivaig kirk and manse, | R. C. |

117. It thus appears as in the highest degree probable that the Parallel Roads of Glen Roy, to-

gether with other similar or only slightly diverse markings in the same district, are the memorials of these glens having once been the beds of arms of the sea, exactly like those of Loch Hourn, Lochnanuagh, and the many others, which at this day serrate the western coast of Inverness-shire. It is interesting to trace in these modern examples the formation of precisely similar beaches to those now lying high and dry in Lochaber. Wherever a steep hill dips down into these narrow seas, the water indents its side; portions of matter fall down from above, and are spread out immediately under the water; and thus in time, by a mere transference of material, a beach is formed, which, if it were elevated above the waves, would show exactly the same sectional outline or profile as the *Roads*. The angle at which the hill meets the water, the nature of the exterior of the hill, and perhaps also the degree of quietude of the water, through the retiredness of the situation from the main sea, may be pointed to as exercising an influence in determining the markings, their vividness, and their permanency. It is surprising in what minute things one may sometimes see a reflection of great geological phenomena. There is an artificial pond in a steep-sided glen near Edinburgh, in connexion with the water-works of the city. In November 1847, this was eleven feet below its usual level, having sunk so much at successive stages, a few inches at a time. Wherever the sides of this lake were steep and of soft

matter, they were impressed with parallel lines of indentation, which could be traced round every little creek and promontory, exactly as the Lochaber Roads. It was a beautiful miniature of the whole phenomena described in this chapter. At one place, where the banks were low and shallow, at the entrance of a rill called the Kirk Burn, there was a perfect example of the ordinary Highland delta, a long slope of gravel, sand, and some clay, cut down longitudinally by the burn, and presenting a succession of levels in the cut, according as the pond had subsided. The whole scene was most instructive; on one hand the lines which the simple Highlanders a few years ago believed to be the hunting paths of mythic heroes, on the other the water accumulations which science, within the last few years, set down as the work of glaciers. How clear and direct is the discourse of Nature, when the true key to the cipher in which she writes has once been discovered!

### LOCH TULLA.

118. In the passage to the Highlands by the western military road, the savage alpine character of the scenery is somewhat redeemed at one place by a lake of considerable extent lying in the bosom of the hills, having the inn of Inverouran on the one side, and the hunting-lodge of the Marquis of Breadalbane on the other. From the water on the north rises the

famed Black Mount, over which the road climbs painfully before descending into Glencoe. Towards the south is a steep and somewhat hollow-sided mountain called Ben Doig, under which a valley opens to conduct away the spare waters of the lake. This lake is Loch Tulla, and the valley is that of the Urchay. The geologist and lover of the picturesque would find much to admire in the great primitive mountains of the district; and the former would observe with surprise that, on the sides of one of the group (the above-mentioned Black Mount), there is a thick though irregular coat of clayey alluvial matter to heights not less than 1000 feet above the level of the sea. We are here about forty miles from Glen Roy.

What chiefly concerns us for the present with the basin of Loch Tulla is the clear and distinct water-marks which can be traced along the faces of the hills, indicating the former presence of a stationary body of water, at levels much above the present lake. Mr Milne, who first announced the character of these lines, speaks of three which he traced all round the lake. He says—"Their perfect horizontality, which I ascertained by a spirit-level, looking at them from twelve or fifteen different places along the banks of the lake—their general conformity in sweeping round headlands, and retiring into valleys or burn-courses—and the extent of flat surface at the levels of the different shelves, afford convincing and irrefragable proofs," that they are what he describes them to be—

beach-lines. Looking only to the lake as the cause of these markings, he is at a loss to discover what could have dammed back the water so much above its present level, but thinks he sees the remains of a barrier at the head of the valley of the Urchay.

In my review of this ground, it did not appear to me that these lines could be described as traceable all round the lake, but I observed more lines than Mr Milne speaks of on the soft hollow face of Ben Doig, and a smaller group appeared on the hill-face above the Marquis's lodge. They appear for the most part, at a distance, as long horizontal banks projecting from the hill-face. When any one crosses a rill-course, it expands to the character of a *delta*, exactly as some similar lines do upon Ben Chlinaig in Glen Spean. They are, in short, wholly of the character of the fragmentary terraces of that district, only one extending so far and so distinctly as to form a kind of link in character between these and the true Glen Roy shelf. I agree with Mr Milne in entertaining no doubt that they are beach-lines, but I dissent regarding the supposed cause. It is no more necessary here than in Glen Roy to look for ancient lake-barriers. The detrital masses in the Urchay valley, to which he assigns that character, are merely the remains of the ancient delta of a burn which there joins the Urchay from the south. All of these lines may have been produced by the sea.

Mr Milne measured barometrically the elevation of his three lines above the lake, and found them respectively 183½, 277, and 474 feet. The series on Ben Doig appeared to me, by rough levelling effected under circumstances favourable for correctness, as follows: 1st, A long low mass with a flat top projecting into the lake, 69 feet. 2d, A terrace-line not of great extent, 86. 3d, A line as on the top of a bank or hummock (unimportant), 160. 4th, A good distinct line towards the east end of the loch, 184. 5th, The principal line on Ben Doig, extending for at least two miles, all at one level, 277. 6th, A short line over one of the chief fragments of the above, 318. 7th, Traces of a line, corresponding with a deltoid formation near a water-fall, 395. 8th, A flat-topped bank intersected by a rill course, 502. There were also terraces and other traces of ancient water-lines, on the Black Mount, at 208, 392, and 502. If I am correctly informed as to the height of Loch Tulla above the sea (given as 630 by a "flying survey" taken a few years ago for a railway), the more decided of these markings may be held as supplying the following series of elevations:—814, 907, 948, 1025, 1104, 1132. Some of these numbers come to a near coincidence with the heights of terraces which appear in other districts; and, upon the whole, the phenomena are of an interesting kind, and well worthy of the attention of any one disposed to examine the problem of the shelf district in Lochaber.

### BASIN OF THE FORTH.

119. Along both sides of the Firth of Forth there occur here and there low sandy flats or downs, called with us *Links*, having a general surface little more than a man's height above the level of the sea, but interspersed with hillocks, probably in all cases of wind-driven materials. Examples are found at Leven and Dumbarnie on the one side, and Musselburgh and Aberlady on the other. From time immemorial, these rough pastoral surfaces have been taken advantage of for playing the healthful game of golf, for which no other kind of ground is adapted. These downs—of which we have seen another remarkable example at St Andrews—are all of one history—the most recent of former sea-margins, and the result of a shift of level not much exceeding ten feet.

At other places along the Firth, there are sandy pleateaux of considerable breadth, or else narrow plains, backed by cliffs of rapidly rising ground, and generally about 21, but in the highest and most inland parts extending to 25 or 26 feet above the present sea-level. Such a sandy plain forms the site of the town of Portobello, (§ 14.) The main street of Kirkaldy extends along what is comparatively a stripe of this height. Many of the other coast towns rest upon stripes and plateaux of the same elevation. The terrace between Newhaven

and Granton, long noted by local geologists as a raised beach, is an example very liable to observation, (§ 14.) Beds of shells (oyster, pecten, bucky, limpet, cockle, &c.) have been found imbedded in the sandy layers of this ancient beach, between Leith and Portobello,* at Borrowstounness, and other places.†

120. The Carses of Falkirk and Stirling are extensive clay plains on the Forth, precisely resembling the Carse of Gowrie, and produced in the same way —that is, by an inwashing of argillaceous alluvium by the river, when the areas of the Carses formed part of the Firth. Seeming to the eye one dead plain, the Stirling Carse is in reality of various elevations, and every where subject to slight inequalities. Amongst the *Crooks* of the Forth below Stirling, it is little more than 10 feet above the sea-level. Opposite to and above Stirling, it is above 20 feet. Several miles farther inland, it comes to a maximum of about 40 feet. The clay forms only the superficial deposit; below it are strata of gravel and sand, and

* Article "Rise in the Beds of the Firth of Forth," *Scotsman* newspaper, November 1834.

† See Mr Milne's paper (Parallel Roads of Lochaber) for many particulars as to beds of shells, broken and otherwise, found at various heights along the shores of the Firth of Forth, and on the Berwickshire coast. They occur in a considerable number of places, as Granton, Prestonpans, Alloa, Kincardine, under 17 feet above the present sea-level; at Dirleton, at about 125 feet; and between Coldingham and Eyemouth, at from 200 to 300 feet. Oysters, whelks, limpets, mussels, and cockles, the most familiar shells of the present sea, are spoken of.

even peat-moss.* Peat-mosses also cover it in many places, and in these graves of ancient forests are found felled trees, bearing the marks of axes, and usually referred to the times of the Romans, because at one place a Roman camp-kettle was found in the clay beneath the moss.

121. The basin of the Firth of Forth every where presents more or less distinct traces of former levels of the sea. It would be wearisome to speak of every place where they exist, and it may be sufficient to mention only a few points where they are peculiarly well-marked, or where novel illustrations may be obtained for the general subject.

122. The large commercial town of Kirkaldy is situated in a bay on the north side of the Forth. As already mentioned (§§ 14, 119), the main street is built upon a narrow raised beach, about 25 feet above the present sea-level. At the west end of the town, behind the ruins of Seafield Castle, there is a fine sandy terrace at 56 feet above the sea. It terminates westward in a mere bank faintly expressed on the general slope of the ground. (See § 26.) Close behind the main street of Kirkaldy itself, is a steep ascent, leading to an extensive plain, perfectly smooth in surface, of sandy soil, and mostly enclosed as gardens and nurseries. The slight seaward inclination of this ground extends between 64 and 85

* Blackadder on the superficial strata of the Forth district.—*Wernerian Transactions*, v. 424.

feet above the sea, thus conforming to a terrace found in many other places. Above this, at 100 feet, is a flat bench of ground having Abbotshall parish church on its front. Right above this, again, is another bench of ground at 125 feet, and somewhat to the eastward, on the road to Leslie, there occurs a broad, flat, and somewhat scooped piece of territory at from 186 to 190 feet. At Leslie, again, which is several miles inland, there is plainly to be discerned to the north of the town, at the base of the slopes rising up to the Lomond hills, a rude terrace composed of gravel, 497 feet above the sea. There are, however, marks of sea-rests at intermediate heights; one of a striking character near the village of Markinch. At that point occurs the lowest ground in the ridge dividing the Eden valley from the basin of the Forth. It is a long extending flat, composed of a deep bed of sand, topped by a moss: the line of the Edinburgh and Northern Railway passes through it. The elevation of this *col*, on the authority of the plans of that railway, is 285 feet above the sea. The rough bench of ground on which the village of Kennoway is situated, a few miles eastward, is of the same height. Farther on in that direction, is Kelly Law, the south face of which is marked with terraces at 389 and 448 feet, while on the moorish ground behind there occurs a plain at 497. At Kinross, near Loch Leven, some miles westward, there is a great plain sloping slightly to the

lake, 385 feet above the sea. It is scarcely necessary to remark, that all of these are at about the normal heights of ancient sea-levels well-marked in other districts. The land-strait at Markinch coinciding with the elevation of a terrace seen in many parts of Scotland, is a valuable fact. It is not less remarkable that the saddle of ground near Forgan, between the Eden valley and the basin of the Tay—over which the Dundee road passes—is 165 feet above the sea, the elevation of another conspicuous terrace.

123. Passing over to the Lothian side of the Firth, there is, a few miles inland, a range of hills—the Lammermoors, Moorfoots, Pentlands—broken by the valleys of the Tyne, Esk, Leith, and Almond, which generally observe a slanting course, having, in the district nearest to the sea, intermediate ridges of soft sloping outline. Along these ridges, and also higher up in the hilly region, what may be called the usual series of ancient sea-levels is marked. Take, for instance, the Esk. At Musselburgh, we have in the Links and site of the town the lowest of these ancient beaches. Behind the town, on the line of the branch railway, is the second plain, somewhat more than 20 feet above the sea; composed of stratified sand, gravel, and shells, precisely like a beach of the present day. In the neighbourhood of Stoneyhill villa, is seen the terrace at 56 feet: in the gorge through which the river passes, it is marked on both sides—all pure sand. The terrace usually

found about 70, but extending up to 85 or 90, appears in great extent between Easter Duddingston and the sea. Repeated to the east of the Esk, and along by Edgebuckling Brae into East-Lothian, it forms one of the finest tracts of land in that rich agricultural district. When the Protector Somerset came to avenge the non-fulfilment of the designed alliance between Edward VI. and the infant Queen Mary, he encamped his army on the front of this ancient beach to the east of Musselburgh, and it was in a hollow carved in it by the Pinkie burn that he gained his bloody victory over the Scots. Along the same beach, at Preston, Prince Charles Edward advanced with the clans, in 1745, to attack General Cope. It is a peninsular fragment of this beach which, forming the site of a range of elegant villas at Inveresk, has obtained, by its fine air and the southern exposure of its escarpment, the appellation of the Montpelier of Scotland. The ground, as exposed in section by the North British Railway, is composed, to the depth of at least 20 feet, of pure stratified sand and gravel, below which deposits there is clay in the neighbourhood. Farther back, near the village of Cowpits, we find a fine plateau of 106 to 113 feet, above which the ground rises rapidly.

[*Environs of Edinburgh.*]

124. Or take the face of the land at Granton, the modern Piraeus of Edinburgh. Here, within a

quarter of a mile on either hand, is the terrace already so much noticed by local geologists, at about 20 feet. Standing on the pier and looking to the slopes which overhang the village, we see a terrace 56 feet above the sea: in a brickfield formed upon it near by, we discover, in the section cut for the work, first a bed of sand and fine gravel, the layers of which are laid down on the slight inclination proper to a beach; second the bed of blue clay, used in the making of the bricks. Pass up the new road towards the city, and at the summit of the slope we find a slightly inclined plain stretching as far as the eye can reach towards the west—a continuation of the great terrace which has been spoken of as passing into East-Lothian. It may be said to hang on the skirts of one of the ridges above described,—one which slopes very slightly down from Corstorphine Hill to Leith. Gentle as the declivity is, this sea-margin can be detected as making a certain indentation across its dorsal summit, about a quarter of a mile to the west of Golden-acre. At West Pilton, moreover, the terraces seen on the opposite coast at 100 and 125 feet are distinctly repeated.

125. In the hollow to the south of this ridge—one containing only a small trickling rill—there is a perfectly flat-topped subordinate ridge at Inverleith farm; or perhaps it might rather be described as a terrace having a slight hollow behind. A similar piece of ground, forming a continuation of the ter-

race on the other side of the Water of Leith, affords site to the Edinburgh Academy and some of the modern suburban streets of the capital. These are peculiar forms of ground produced by the sea when it stood about 70 feet above its present level. It is easy, at Inverleith farm, to perceive a terrace at corresponding height in the fields west of Stockbridge. To the same period is to be referred the ground which once formed the Botanic Garden in Leith Walk, memorable for the reference made to it by Mr Playfair, in his *Illustrations of the Huttonian Theory*. On the shores of the Firth of Forth, he says, "many monuments appear, which would carry the difference between the present and the ancient level of the sea to more than 40 feet. The ground on which the Botanic Garden of Edinburgh is situated, after a thin covering is removed, consists entirely of sea-sand, very regularly stratified, with layers of a black carbonaceous matter in their lamellæ, interposed between them. Shells, I believe, are but rarely found in it, but it has every other appearance of a sea-beach."*

126. In Lothian, as in many other districts of Scotland, there is a tendency to a quicker rise in the ground after passing the first 110 feet of vertical elevation above the sea. This fact, which has already been adverted to (§ 24), seems to indicate a long

* Works of Mr Playfair, i. 434.

pause of the sea at about that level, of which there is ample additional proof in such phenomena as the Straiton plateaux in Fife, and the great gravel terrace round the shores of the Moray Firth. We see low ground continued up to this height behind Musselburgh, and then a rise takes place. So does low ground advance to this height all round the skirts of Arthur's Seat, and the eminences on which Edinburgh is situated. And every where does it present a deep bed of stratified sand. It may be said to form true flats on Lochend farm and at Holyrood Palace, also at Gayfield House. The lower part of the New Town, along the line of London Street and Great King Street, is situated upon it, the comparative flatness of the ground having probably helped to determine the laying out of those streets.

127. The reader may thus be in some degree prepared to hear that the markings of ancient sea-levels can be traced with tolerable distinctness in several parts of Edinburgh, both in its ancient and modern districts. Undoubtedly we are to understand that ground is liable to considerable change when a town is built upon it. At the same time, we often see it little disturbed by the laying down of buildings, and, certainly, after these are erected, it is rather likely to be preserved than disturbed. If, however, we see, in the surface of a town built on so many levels as Edinburgh, spaces of considerable extent exhibiting a remarkable flatness, and forming continuations

of true flats from the neighbourhood, or at least observing the same levels, there can be little difficulty in setting them down as true sea-markings. We have seen the terrace at Inverleith farm continued into the suburbs at the Academy, and the terrace at Gayfield House prolonged into London Street. It may further be observed that the flattening which occurs in the great slope of the New Town at the Queen Street Gardens corresponds in general elevation with a terrace seen in numberless places at 165 feet above the sea. In the eastern division of these gardens, where the modern decorator has not been employed, there still survive masses much resembling fragments of a true terrace at about 186 feet. Queen Street, in its western divisions, is of this height; so is Melville Street. These are facts calculated in themselves to make little impression; but when we pass out of town, and, a little beyond Dalry, find a true gravel terrace, flat and of considerable extent, at that elevation—they acquire some interest. This Dalry terrace has lately been formed into a public cemetery; but a larger mass of it may be seen entire, to the westward, near Gorgie Cottage, and it is only somewhat less distinctly repeated on the opposite side of the valley amongst the Murrayfield villas. Still closer to the town, within a garden at Cochrane's Livery Stables, near the Haymarket, a patch of it is to be seen.

128. This is, for a local investigator, perhaps too

tempting a subject; but I shall nevertheless proceed to state such further particulars as I think rest on tolerable evidence.

129. The church of St Cuthbert's, occupying the site of one of the oldest religious buildings in this part of Scotland, is placed on a piece of ground which answers to the beach between 165 and 170 feet. Another mass of it may be observed in the gardens to the eastward. The fine terrace now occupied by Princes Street, being a little above 200 feet, corresponds with one which has been repeatedly alluded to. Here a very curious consideration occurs. When the sea stood at this height, and at the next lower level (186-192 feet), it would beat around the pillar-like basaltic mass on which the Castle is built. A current would perhaps exist along the valley between the New and Old Town. Now it is well known that some parts of the primitive face of the rock towards that valley are smoothed in a peculiar manner, evidently by some agent applied laterally. Were the supposed current laden with ice, it would have such an effect. I have taken observations as to the height of the principal smoothings, and find they occur just a little below the level of Princes Street.

130. The Old Town, as is well known, is built on a sloping ridge or *tail* of a mile long, stretching eastward from the Castle rock, and extending in vertical height from 108 feet above the sea at Holyrood Palace, to 325 at the Castle hill. It may beforehand

seem very unlikely that ground which has been the site of a city for the most part of a thousand years, and undergone all the changes incidental to frequent renewals of the buildings, should continue to exhibit with any distinctness traces of such peculiar natural markings as are the subject of this work. Nevertheless, having remarked a series of flats, or, as it were, landing-places, in the general ascent of the principal street which runs along the top of the sloping ridge, I deemed it not impossible that they might be primitive features of the same character with indications which I had observed on similar hill-faces as yet in a state of nature. It appeared in the very first place as favourable to the idea of their being natural features at all, that, out of the four flats, two were the sites of ancient public buildings of an important character, such as the best or most convenient ground would be selected for, while a third formed a demarcation between the city and its ancient suburb, the Canongate. The crucial test, however, evidently lay in the levels. If these corresponded with those of ancient beaches well-marked elsewhere, and especially in the neighbourhood of the city, then was it tolerably certain that the flats in question were indentations made by the sea, in the course of its subsidence to the present level. If it should prove otherwise, they might be presumed as accidental, or the result of causes not concerned in the present inquiry.

131. Now the reader has already seen many ex-

amples of beaches of this range of elevation described. Let us, before taking any further notice of the Old Town indentations, advert to several markings in the immediate neighbourhood of the city.

132. Just beyond the suburb of Newington, an obscure rill called the Powburn pursues its way through a little valley, observing an easterly direction. On the upper brink of this valley, to the north, there is a terrace crowning a steep slope or bank, and presenting all the usual appearances of an ancient sea-margin. Part of it having lately been laid out as a public cemetery, we have had opportunities of ascertaining that the ground to a considerable depth is composed of a clayey sand. This terrace appears to be 170 or 171 feet above the sea.*

133. Passing westwards less than a mile, we find, behind Grange House, a terrace, more faint, yet sufficiently distinct, which can be traced along till it crosses the Canaan road into the grounds connected with the villas of that district, and so onward to Falcon Hall; on the other side of the valley of the Jordan burn, opposite to these villas, the corresponding terrace is prominently marked; the two sides of an ancient creek of the sea, when that element stood rather more than 280 feet above its present level. The same flat is rudely marked on the skirt of the

* In ascertaining the levels of various places in and around Edinburgh, I have been much assisted by a professional work of great accuracy, *Moffat's Landscape Plan.*

Blackford Hill, at Libberton West Mains. These markings, however, are all of them tame, compared with a grand terrace of the same height, on the north side of the little valley beyond the Libberton ridge. The fine old mansion of Moredun is situated upon it: it extends with great distinctness a good way eastward, affording site to Mr Lothian's villa at Ferneyside, but fades away on the slope under Edmondstone House.

134. When the sea beat on this terrace, the hill on the summit of which Craigmillar Castle is situated, presented only a little rocky isle above the waves. This isle consisted of a mass of sandstone, which forms a vertical precipice to the south, just under the walls of the castle. A good way out from the bottom of this cliff, in all three directions, is a flat on which the castle garden, with its ancient quaint devices, may still be traced. That flat is 280 feet above the level of the sea. Answering in elevation, it has been too much disturbed by the hand of man to present the required linearity. I am assured, however, by Mr Smith of Jordanhill, that the overhanging cliff bears much of that appearance of sea-wearing which he has observed in similar precipices that either are now, or have been at a comparatively recent period, exposed to the dash of the billows. Whether it does so or not, there can be no doubt that it once was exposed to this action, as the sea could not have laid down the Moredun terrace opposite, without at the

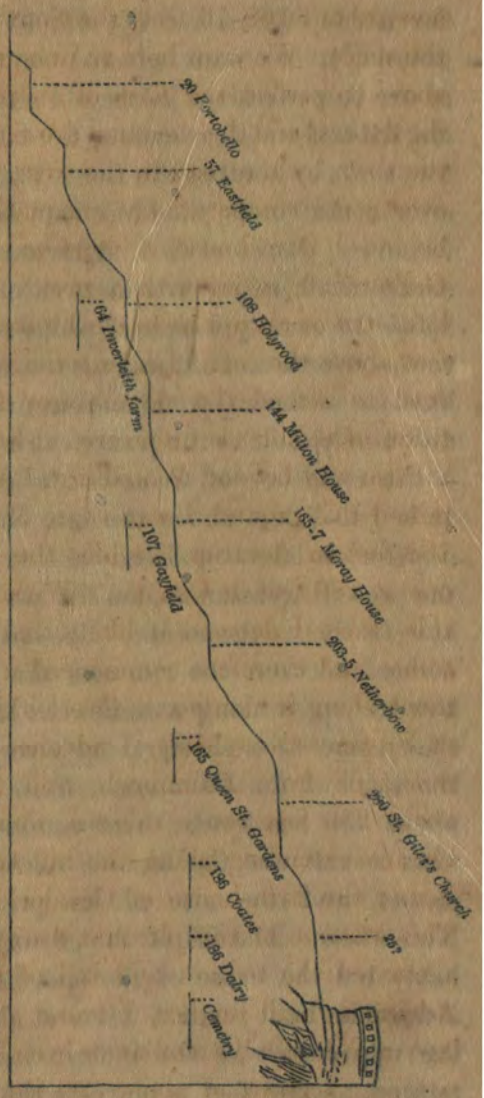
same time rolling its waves along the Craigmillar garden, in which case it must have impinged on the cliff at every high tide. How little could Mary, when she walked in this garden, pondering on her conjugal infelicity, imagine that we should in time learn of natural transactions which took place upon the same spot ages before her period.

135. If, in the winter season, when the ground is comparatively clear for observation, we take a station at Dalkeith, and direct our eyes to the southward slope which there rises above the Esk valley, and along which the Kelso road proceeds, we shall very readily perceive that it is, as it were, laid out in flats, the straight horizontal outlines of which give a strong character to the ground. Some extend westwards and fade on the hill-side; others stretch far in the other direction, till they terminate on the sky line. To the east of Dalkeith, this terraced hill-face is distinctly seen rising out of a broad plain, which seems to form no inconsiderable part of the park around Dalkeith Palace, and of which there is also a large section to the south of the park wall, the Duke's Kennel being situated upon it. This is from about 144 to a few feet more above the level of the sea. It is an unmistakeable ancient sea-margin in its form; as to its constitution, the cutting for a coal mine near the kennel gives 40 feet of sand slightly mixed with clay. The street of Dalkeith itself and the flat ground to the south near Woodburn, form another

level, about 168-73 feet; the South Esk intersecting the space. We want here an unequal slope below and above to perfect the *form* of an ancient beach; but the flatness and the elevation are significant. Leaving the town by the road to the west, and after passing over some comparatively unequal ground, we find, behind a farm-house, a short way before coming to Gallowshall, a flat with a pretty steep, though not lofty cliff or abrupt ascent behind: this is about 213 feet above the sea. Leaving the town by the Kelso road to ascend the slope above described, a repetition of this flat is discovered at Steven's New Mills, a little way beyond Woodburn. When I first examined this ground, I was aware of no terraces above 168 feet in elevation, besides the single example of one at 280 feet at Canaan. Without seeing any on this slope, I deemed it likely that it would present some, and therefore commenced a careful measurement along its surface. Overlooking the small flat at Steven's New Mills, I advanced to the seventh milestone from Edinburgh, and there, being just about 280 feet above the sea, found a great broad terrace extending along the hill-face in both directions; the farm-house of Cowden situated upon it. This was one of the pleasant discoveries which have alleviated the tedium and toil of the investigation. Advancing still further, I found at the colliers' village of White-hill a similar or even broader and more sweeping terrace, at about 390 feet above the sea—

being the first example of a new terrace, for which *confreres* were afterwards found.

136. Let us now return to the street-covered ridge of ancient Edinburgh. We start at the plain of Holyrood, 108 feet above the sea. From hence the street ascends with no well-defined interruption, till we reach Milton House, where there is a flat of at least 100 yards in extent. This is 144 feet above the sea-level, agreeing with the plain at the Duke's Kennel, and with several markings in




SEA-MARKINGS IN EDINBURGH.

the north of Scotland (§§ 81, 99). As being flat ground, it has been selected for the sites of some of the best mansions in the old city, particularly the elegant house and grounds of Lord Justice-Clerk Milton, and the hotel of the Lords Panmure, in which a greater than earls, the illustrious Adam Smith, dwelt for several years and died. After another ascent, there occurs another flat, even more extensive. From probably the same principle of preference, this gives site to the church and old court-house of the Canongate; likewise to the supposed ancient mansion of the Gordon family, and to the palace of the Earls of Murray —the residence of Cromwell when in Edinburgh. It is 165-7 feet above the sea, corresponding with numberless terraces, already and to be described. In the preceding instances, the flat has been superficially as extensive as the ascent. The street has been fairly divided between the rise and the level. We now, however, pass along a somewhat longer ascent, and then come to a short, though very decided flat at the head of the Canongate, from 202 to 205 feet above the sea-level. The commencement of the next ascent was the eastern extremity of the city proper, and the site of its principal gate, the Netherbow. The fall of the ground to the flat probably was the cause of the spot being selected as a defensible limit; but I deem it also probable that the upper part of the indentation has been obliterated, as 205 feet is scarcely the highest range of this beach. Perhaps, when all is considered, the

wonder rather is that there is any marking preserved here at all, than that it is slightly defective in point of measurement. Another comparatively long ascent, and at St Giles's church, we come to a fourth flat—one unusually broad and well-marked. Here the principal public buildings of the ancient city were congregated: the parish church (afterwards cathedral), the Tolbooth or town-house (both of them structures of great antiquity,) and the Parliament House and courts of law. Here the ground has been slightly lowered in modern times, to the effect of softening the abruptness of the original transition from the ascent to the flat. The original height at the flat was about 280 feet above the sea-level—a perfect coincidence with the terraces at Canaan, Moredun, and Cowden; as also with examples in other districts. It may be added parenthetically that the tract of table-ground on which Heriot's Hospital and the Charity Workhouse stand, is precisely of the same height. Thus is completed the series of indentations in the Edinburgh ridge, all of them, it will be observed, coincident in elevation with distinct memorials of sea-margins in the surrounding country, near as well as far. It seems reasonable, accordingly, to infer, that these marks were made by the tooth of the sea, at the pauses which it made in descending from between 300 and 100 feet over its present level. When we reflect on the many historical associations connected with the last group of buildings, it becomes a curious consideration that the

locality of them all, from the commencement of the civil war with the Liturgy riots, down to the seizing of Porteous in his prison, as well as the localisation of the supreme law-courts of the country, should have been, to all appearance, determined by a circumstance so different in its relations as the wearing of the sea on the face of a drift-formed hill, in an age so remote in comparison with the eldest of historical events!

137. Mention has been made of a gravel terrace at Dalry Cemetery and Gorgie Cottage, 186 feet above the level of the sea. The channel of the Water of Leith being near by to the westward, we may safely presume that the gravel is connected therewith. This stream descends into the great trough of country west of Edinburgh, through a cut which it seems to have formed in the lofty side of that valley, adjoining to the Pentland Hills. If we stand in the plain below, near Corstorphine, we see a conspicuous flat on the rise towards these hills. On near inspection, it is found to be an extensive elevated plain, stretching from Comiston west by Colinton towards Malleny, with no interruption but that of a deep narrow cleft in the subjacent sandstone at Colinton, through which the stream finds its way. This plain, the surface of which is wholly of sand, gravel, and clay, is in its fore-parts, as at Colinton House, 380 feet above the sea; whence it rises a few feet towards the inland part. It is, in short, a memorial of the same sea which stood on

the terrace at Whitehill above Dalkeith, and which fashioned the flat-topped mass at Brecklech, near the mouth of the Spean in Lochaber (§ 100). We shall see memorials of the same sea, miles in extent, on the banks of the Tweed and Gala (§ 171), besides others beyond the bounds of our island. The level of that sea seems to have been about 393 or 4 above the present.

138. The matter is here chiefly worthy of notice, because of another geological fact recently brought to light near Edinburgh. On the south side of Arthur's Seat is a well-known cliff of basaltic pillars called Samson's Ribs, forming a sort of shoulder to the hill. A drive winding round the hill, passes like a baldric over this height, presenting, perhaps, the most romantic views which are to be enjoyed from a carriage near any capital in the world. When the road was making, it was necessary to cut down the hollow over the shoulder for about 15 feet. The first matter removed was debris from the hill-face; below this was a bed of brown tenacious clay, containing angular fragments, some of which had come from a distance. When the trap was laid bare, it was found to be smoothed as by some rude polishing instrument, with horizontal scratches on the smooth surface! The curved bottom, and the sides for a man's height upward, all bore this appearance. Even a narrow trench which I detected at one place in the bottom—the polishing power had gone down into it and made all bare and plain.

Included crystals were as usual cut through. Where there had been great roughness, prominences were polished at top, while the hollows between remained untouched. It was evident to all beholders, that some mechanical agency had been applied laterally or horizontally in this trough of living rock: but what was it? Professor Forbes declared the perfect resemblance of the appearances to those produced by glaciers in the channels which they fill at this day in the Alps. But how should a glacier come up the side of a hill and over its shoulder, as would be necessary in this case? We are not here in the downward hollow of a hill face, with smoothings and scratchings in a descending direction;—the idea was clearly inadmissible. Mr David Milne contended that the presence of water was shown by the clay-bed lying immediately above the smoothed rock.* He deemed it more likely that the phenomena were the effect of icebergs crushing under press of currents through the narrow gorge formed by the rocks, at a time when the sea stood at a certain height above its present level. It did not occur to me for a long time after, to examine if the top of Sampson's shoulder corresponded in elevation with any of the ancient sea-surfaces which are here chronicled. Obviously, if it did so, there would be no inconsiderable addition to the probability, that water had been concerned in the phenomena. Having authentic levels for ground near by, I experienced no difficulty in

* Proceedings of Royal Society of Edinburgh, April 1846.

ascertaining that a sea 393 or 4 feet above its present height would just submerge the trough with all its smoothings. Now, that this was a former elevation of the sea we have incontestible proofs; that it was one of vast continuance, the masses of Brechlech and Colinton, and the broad terrace at Whitehill, are already specified; besides which, some evidences remain to be noticed. Undoubtedly, then, Sampson's Shoulder was once a narrow shallow passage of the sea. It follows that, if the sea of this period was charged with icebergs, and observed easterly or westerly currents, a crush of such matter might be continually pressing through this passage, rising in it and falling under the flow and ebb of tides, and thus wearing off every prominent roughness from its sides. It would be a case much like that of the smoothings on the north face of the Castle rock. It may be for other observers to ascertain how far smoothings in like manner confined in their extent, may be accounted for by these authentic records of ancient sea-levels.* The facts here set down, speak

* On the islet called the Calf of Man, there is a mass of sand, gravel, and boulders, about 50 feet across, laid down on an elevated point of the schist composing the district. This mass is about 13 feet thick and stratified, the larger masses being nearest the surface. Most, if not all the rocks are foreign. Its situation is estimated at 372 feet above the level of the sea. The Rev. Mr Cumming, who describes this remarkable object, can only account for it by supposing it to be the produce of a *grounded iceberg.—Proceedings of Geological Society, Jan.* 1847.—If the height of the mass itself is, as I apprehend, to be added to the general elevation, this supposed iceberg would float in a sea just about the height here spoken of, when it was stranded at the place where it deposited its burden.

of the time of the fall of the sea to its present level as one in which our geographical area was distinguished by a colder climate—shall we say, the decadence of that admitted glacial era expressed by the Drift?

[*Parishes of Borthwick and Crichton.*]

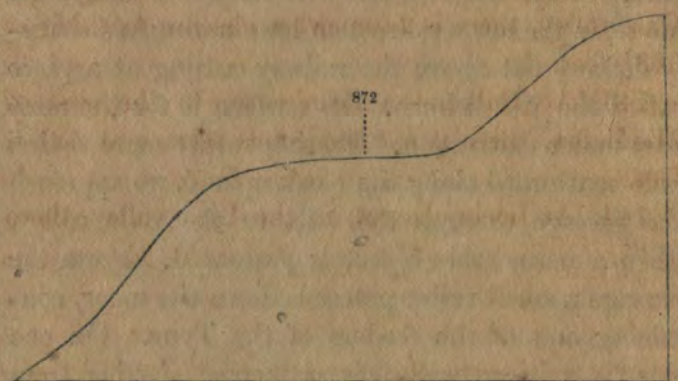
139. In the rise of Mid-Lothian towards the Moorfoot hills, the parishes of Borthwick and Crichton present, of a character much resembling that at Colinton, and seamed like it by rill-courses, namely, at the heads of the Tyne, South Esk, and their tributaries. The rapid rise of the ground in this district must be remembered by all who have travelled along the road to Galashiels: it will now be scarcely less palpable to those proceeding along the Hawick Railway, which mounts through these plateaux by a gradient of 1 in 75 for several miles, till it passes over the *col* into the Gala valley at 864½ feet above the level of the sea. The character of the superficial formation is brought strongly into view by this railway,—one valley requiring an embankment of 122 feet to bring it up to the level of the rails, while some of the cuttings through the higher ground are not less than 77.

140. In advancing to this remarkable region from Fushie Bridge, we first come to a little valley watered by a small tributary of the Esk, under Middleton House. It has a terrace on each side at 656 feet above the sea. On the south side of the valley is

another at about 687 feet. As a third line higher still, we take in at the same view a great plateau, forming what may be called the frontier of Middleton moor, and on which Middleton House is situated, this being generally about 760 feet above the sea, though rising one or two feet more at its most inland part. It extends east and west fully a mile from the house, in the former direction terminating in a sharply defined flat above the railway cutting at a place called the Witch burn. Its surface is for the most part under cultivation. Passing rather more than a mile southward along the bleak upland, we approach the passage through the hills to the Gala valley, when a remarkable object is presented. From the passage a small valley proceeds down the moor, containing one of the feeders of the Tyne. On one side, is a broad well-defined terrace starting from

TERRACE AT COWBRAE-HILL.

the hill-face,—the farm-stead of Cowbrae-hill seated upon it; on the other, is a conspicuous linearity distinguishing this part of the moor from every other except the flat at Middleton. And these two objects correspond in elevation. This is an unequivocal sea-marking at about 872 feet above its present level.*




SECTION OF TERRACE AT COWBRAE-HILL.

It possesses a peculiar interest as so nearly coinciding with a neighbouring hill-passage, or *col.*

141. And what is the constitution of the ground on this elevated plateau? The railway cuttings give a most impressive answer to the question, in revealing successive layers of pure sea-sand, gravel, (these layers containing streaks of pounded coal,) and blue

* Measurement obtained from the railway plans, up to the last few feet. In the other measurements of this district, material aid was derived from the same source.

clay containing angular fragments and boulders. We find Middleton moor to be one wide-stretching deep deposit of diluvium, surmounted by sand and gravel. In some places, it may be remarked, the gravel-beds are considerably inclined, or wavy, and here and there a thick layer is seen under the blue clay.

142. On the hill-faces forming the passage into Gala valley, there is a somewhat obscure marking at 968½ feet.

143. At Halkerston farmhouse, to the west of Middleton, there is a conspicuous terrace at 821-6 feet.

144. At Lochquharret, in the Tyne valley, there

TERRACES AT LOCHQUHARRET.

is a well-marked terrace at 628 feet,—repeated on the other side of the vale, behind Crichton Castle. Above Lochquharret is a shorter terrace, 706 feet.

145. All of these heights are relative to others. The 821-6 feet terrace is repeated in the Glencorse valley, among the Pentland Hills, to the north of the Compensation Pond.* It is also worthy of remark, that the broad-topped hill between Dalkeith and Crichton, distinguished by a Roman camp, which gives name to the spot, is identical in height with the Cowbrae-hill terrace,† while a flat sky-line to the eastward is taken up by the level when fixed at Halkerston. It is somewhat remarkable, that the Halkerston flat, thus twice repeated in Lothian, is about the same level with the summit of Arthur's Seat.

[*Falkirk and Stirling.*]

146. The form of ground which has been described as appearing near the sea on the front of a large part of Mid-Lothian, is continued on the south side of the Forth in both West-Lothian and Stirlingshire. It is strikingly seen above the old burgh of Queensferry. Farther to the west, it is intimately connected with a vertical terrace or plateau, the continuation of that which has been spoken of as coming up to the skirts of Arthur's Seat, and appearing in other places in and about Edinburgh, at about 108

* Measurement chiefly from the plans of the Edinburgh water-works.

† This height is given in Knox's Map of the Basin of the Forth, at 876 feet above the mean sea-level.

feet above the sea. The whole phenomena are presented in an interesting form in that great *sinus* of the land which contains the Carse of Falkirk, and through which the Carron proceeds to join the Forth. Standing on the shore of the Firth, we see here—first a great argillacious plain (the Carse), generally about 20 feet above the sea—the exact analogue of the Carse of Gowrie already described—covered with farms and gentlemen's seats; next, wavily skirting and hemming in this region, a steep bank, the top of which forms a level terrace; beyond this, hills of gentle ascent and slight elevation. This terrace expatiates, in the immediate neighbourhood of the Carron, into a considerable plain, part of which forms the Tor Wood, famous in Scottish history. It is, however, properly speaking, two terraces; for in some places we find the front bank from 85 to 90 feet, while, behind, it is 114, or perhaps a very few feet more. At Falkirk, this front terrace, the strict co-relative of the beach at Granton and Easter-Duddingston, is seen on the north side of the town, bearing the Catholic chapel, the school, and other buildings; also extending along the Edinburgh road at Callender. Then, again, the principal part of the town, and certain nursery-grounds behind, are on the back terrace at 114 to 117 feet. To the eastward, under Bantaskine House, we find the lower one prevailing; the village of Camelon situated upon it.

147. The great breadth of the terrace in this district, and its arenaceous character, are facts connected with the inlet of the Carron. We see here, extending for miles on both sides of that river, at the lower part of its course, the remains of the detrital sheet which it spread out under a sea about 117 feet above the present. Through this mass, there is now a trench for the passage of the extended river, of varying breadth, and the sides of which are like walls and buttresses of sand, stooping down to a low floor or haugh, which the stream occasionally floods. A recess in the face of this high alluvium, below Larbert bridge, is spoken of by tradition as an ancient harbour; and the remains of a boat and pieces of broken anchors have been found embedded at the spot.* And undoubtedly, when the sea stood at one of its lower ancient levels, just sufficient to submerge the Carse, it *would* form a creek in this valley, sufficient to float small vessels. Having already seen some facts which favour the idea that the last shifts of relative level between sea and land may have taken place since the country was inhabited by human beings, there is the less reason to hesitate as to the bearing of this additional evidence. The anchor and boat-hook in the Carse of Gowrie, the horn handles found with the whale's bones in the Carse of Stirling, and the boat

* Nimmo's History of Stirlingshire, 2d edit., p. 74.

and broken anchors found near Larbert, all go to one point, making it likely that the inhabitation of our island took place before the last thirty or forty feet of its vertical elevation was gained from the ocean.* We may well pause, however, before attaching consequence to a local tradition alluded to in the *Statistical Account of Falkirk*, which speaks of Camelon having anciently been a sea-port; even though we are told of "fragments of anchors and boats" having been found there. The topographical appearances of the district are so suggestive of an ancient sea playing on the terrace at Camelon, that the idea could scarcely escape the most simple minds; and thus a *might be* may have been, in the usual manner, transformed into a *was*, which sundry doubtful objects excavated from the ground would be interpreted as supporting.†

148. The valley of the Carron contains two remarkable objects, the celebrated Mounts of Duni-

* "The Carse of Stirling was cultivated and measured in the 12th century."—*Nimmo's History of Stirlingshire.* This editor quotes from Trivetius's Chronicle, an account of the invasion of Scotland by Edward I., in which it is implied, that the English cavalry could not make their way through these "loca palustria" in the winter season.

† "Some years ago, a complete boat was found near Falkirk [in the Carse ground, I presume], five fathoms deep in the clay; and anchors have been dug up in the ground between Stirling and Alloa."—*Beauties of Scotland*, iii. 419. Mr M'Gregor Stirling, in his notes to Nimmo's History of Stirlingshire, written before geological speculations were so familiar as they now are, expressed his belief that the ocean once occupied the vale of the Forth beyond Gartmore—a spot situated at the west extremity of the Carse, nearly twenty miles from the present sea at the nearest point.

pace, which are intimately connected with this inquiry, though heretofore supposed rather to belong to the domain of the antiquary. What follows on this subject has already appeared in a popular journal:—

149. "I lately visited Dunipace, in order to behold these famous miniature hills. Leaving the Stirling road at Larbert, we walk about a mile up the valley of the Carron rivulet, on its north side; a beautiful specimen of the simple Scotch lowland valley, composed of—first, the sparkling stream, murmuring over its pebbly bed; then the flat margins (*haughs*), of varying width; next, steep banks rising from the haughs, glowing with the primrose and furze bloom; finally, a flat stretching away from the top of these banks, to melt in the distant hills. Rich ornamental foliage half screens the road, which winds first along the steep bank, and then through what may be called the floor of the valley. At length we pass a promontory of the steep bank, and find ourselves in a comparatively wide piece of flooring, most of which is occupied by a gentleman's park. Here the road crosses by a bridge to the other side of the water: formerly, there were only *steps* for this passage; and it was by the *Steps of Dunipace* that the Highland army crossed in 1746, when making its stealthy advance to fight Hawley at Falkirk. Dunipace House faces us in the park; a pretty little mansion. We involuntarily recall its proprietor of 1746—poor Sir

Archibald Primrose, executed at Carlisle in that memorable year, regretting nothing but the coming orphanhood of his children, and his having so far given way to bad advice as to plead guilty of an imputed crime which his conscience told him to be a virtue.

150. "Between the house and the bridge, about fifty yards from the river side, two wooded eminences start up from the green bosom of the park, having an old churchyard nestling almost between them: these are the Mounts of Dunipace. The eye is at first at a difficulty in making out the objects, in consequence of the wooding, which I take leave to pronounce a mistake and a grievance, as it only disguises, and reduces to commonplace, what would otherwise tell as extraordinary and not unpleasing objects. Abstracting the wood in our mind, we find that the mounts are of different form and size—one circular and conical, with a flat top, and between fifty and sixty feet high; the other a lengthy heap, of somewhat less elevation, and covering a much larger area. The substance is gravel and sand. The two are at unequal distances from the river; they stand in a line more nearly transverse to that of the vale than coincident with it. All around them the ground is perfectly flat, but between the two mounts there is a slight rise or swell.

151. "Singular in form and situation, it is no wonder that these hillocks should have attracted the

attention of inquiring minds, and given rise to much speculation. As far as I am aware, they were first described by George Buchanan, who, having lived many years at Stirling while conducting the education of James VI., would probably visit them frequently. He makes no doubt that they were thrown up by the hand of man. Neither did it appear doubtful to him that the etymology is *Duni pacis*—'the hills of peace;' though how so classic a wit as he could suppose the Celtic word *dun*, a hill, to be associated with the Latin word *pacis*, I am at a loss to comprehend. Satisfied, however, with this etymology, and adverting to the curious temple at a lower point on the Carron, which was supposed to have been erected by the Romans to the god Terminus, the learned historian concocted a very plausible tale, to the effect that the Emperor Severus here ratified a peace with the Scottish king, Donald I., and that these mounts were erected in commemoration of it. This view of the matter remained unchallenged for two centuries, when at length Sir James Foulis of Colinton published a paper in the Transactions of the Scottish Antiquarian Society, scouting the idea of the Romans and natives clubbing to make up a word; and also denying that the former nation ever raised such monuments on accomplishing treaties of peace. The mounts he equally presumed to be artificial, but he believed them to be sepulchral in character. 'I conceive,' says he, 'that the tumuli of

Dunipace were raised over the people who had fallen in battle, each army raising one for its own men, and therefore gave them the name of *Dun-abas;* that is, *Hills of Death.*' Such was antiquarianism amongst us sixty years since; a battle *imagined,* then these hills *presumed* to be memorials of it. No evidence looked for beyond a doubtful etymology. The only remark of any value made by Sir James is, that a similar mount at the confluence of the rivulet Ury with the Don in Aberdeenshire, is called the *Bass,* a word nearly resembling certainly one portion of the name of Dunipace. Within the last few years a Danish antiquary came to see these mounts, and, after examining them, pronounced them sepulchral tumuli. He expressed the greatest anxiety to have them penetrated through the middle, avowing his full conviction that tombs of great personages of antiquity would be found within.

152. "It is extremely interesting to trace the progress of speculation on this subject, during the time when no one dreamt of operations of nature being concerned in bringing about any such appearances. Objects of so peculiar a form must have excited wonder in the people who first came near them. Unavoidably, thereafter, they would become the subject of mythic tales. Then comes an early historian, whose learned conjectures are only a little more rational than the rustic legends. Next we have antiquaries puzzling and dreaming over the

phenomenon, but unable to make any thing like common sense out of it.

153. "Behold, at length arrives the naturalist—the man of science—who deems it necessary to inquire, in the first place, if these objects are really, as hitherto presumed, works of men. Masses covering two Scotch acres, the tallest between fifty and sixty feet high, must contain a pretty large quantity of earth. For a rude, thin-spread people to throw up such piles, would not be much less of a task than for a civilised people, like the Egyptians, to build the Pyramids. Why, moreover, does the neighbouring ground show no trace of the hollow out of which the earth must needs have been dug? Artificial, then, as the Dunipace hillocks appear, and notwithstanding that our early ancestors were in the custom of raising tumuli (though of a smaller size) over the dead, it seems but right that we should exhaust the possibilities of a natural origin before we are driven to the opposite. Now, so far from its being difficult to discover natural means for the production of these hillocks, it chances that the means are remarkably obvious; at least they are so in a modified sense. That is to say, it might be easy, when natural means were not suspected or thought of, to overlook them; but the case is different when we look for such means, and are a little instructed as to the agencies by which changes in the earth's surface are continually in the course of being effected.

154. "The fact is simply this. The immediate valley of the Carron is a hollow cut out by the river, in a tract of ground which extends a great way at nearly one uniform level, though slightly inclined in the direction of the Firth of Forth. When we stand on the bank of the river, we see sections of this plateau on both sides, rising about 60 feet, and, as formerly mentioned, enriched with the bloom of the furze and primrose. Look below the surface of these braes, and you find that they are composed of gravel and sand; in fact an ancient alluvium—the deposit of some Carron of distant ages, when the land was at a lower relative level than at present, and the surface of this plateau was a beach or sea-bottom. On the rise of the land, the present Carron began to cut out its own hollow. It has done so with the irregularity usual in such cases; here carving only a narrow channel, there sweeping out an amphitheatre of half a mile's extent. Accordingly, the braes which I have spoken of are in some places straight, in some places curving; in some instances, between two curves, there is a promontory starting forward almost to the brink of the river. One can see that a little perseverance of the stream in attacking the side of one of these curves would enable it to force its way through, and so *transform the promontory*, as it were, *into an island;* in which case the result would be a mount exactly like one of those at Dunipace, left standing in the midst of the lower floor of the valley.

Such is precisely the history of these mounts. They are simply remnants of the ancient alluvium. The river, in its many floodings and shiftings, has at this place broken through a narrow promontory at two places (remember their transverse direction in the valley); one has been left short and round, the other oblong and more ridge-like. In the former, the wearing of the flood around the base has taken down the original surface only a few feet below the altitude observed by the neighbouring braes (this I ascertained by the level); in the latter, the wearing has thinned the mass so much, that the upper surface has suffered more considerably. Then the slight rise in the ground between the two mounts is nothing but a further memorial of the promontory-like form which the ground at one time bore. Thus the mounts, it will be observed, are not things which nature has directly made in their present form. This it might be difficult to conceive. But considering them as remnants left by nature out of a greater mass of debris which she had previously accumulated, how easy seems the process!

155. "It has already been remarked, that the mounts are composed of the same mixture of sand and gravel which is found in the opposite braes. They are, in short, of the same material as the ancient alluvium out of which the valley has been scooped. This, it may be said, is no decided proof; as, on the presumption of artificiality, the material would ne-

cessarily be that found at hand. But it happens that the Dunipace mounts are, after all, not solitary specimens of their class. Mr Watson, the parish schoolmaster, in the *New Statistical Account of Scotland*, states that 'in the immediate neighbourhood there are several similar, though less remarkable, earthen mounts. About two miles to the westward of these hills, there was a very beautiful one about forty feet in height, and covering nearly three roods of ground, said also to be artificial. This hill was mutilated from time to time, for the repair of roads and other purposes. The strata of this hill were carefully observed during its removal. These were so regular, as if rising out of, and gradually returning again to, similar strata in the circumjacent level ground, as to afford conclusive evidence that the hill was not the work of man.' That this evidence is conclusive as to the particular mount in question, will be admitted by all who know aught of geological science; and undoubtedly, if the Dunipace mounts are of the same constitution, the question is equally settled regarding them. It is not unworthy of remark, that a parish farther up the vale of the Carron bears the name of Denny, apparently from the number of eminences formed there by the cutting down of the ancient alluvium, the word being but slightly changed in pronunciation from one which stands in Gaelic for *hills*; hence, likewise, the English word *downs*, applied to sandy hillocks, the name of the county

*Down*, which is a group of hills, and the many other names of places in which the syllable *dun* figures, either singly, or in connexion with other syllables. One might weary himself and his readers in efforts to make out the full etymology of Dunipace. I shall cut the matter short. It may be, as Sir James Foulis surmised, *hills of death*, alluding to some tragic occurrence; or it may be, as probably, *dun-na-peasg* —'The hill of the notch or cranny,' applicable to a former state of the masses, when they had not been so much separated from one another. That they may have been more connected in times not very remote, is far from improbable, as Buchanan speaks of a mass of the lower hill being taken away by a flood in his time.

156. "I may perhaps be thought to have treated this subject at too great length for its importance. Let me be permitted the remark, that the interest does not lie in the mere question, whether these two trivial hills be artificial or natural, but in the view we here have of a progress of the mind of man in passing from the legendary and superstitious to the natural and rational. It is gratifying to observe such an example of the light which modern science is throwing upon matters which only excited helpless wonderment, or led to vain dreams, in our ancestors. For the rude grace of the old legend is now substituted an exact kind of knowledge, leading to equally romantic conceptions of a different kind; for who

can learn, without far higher wonder, of the great physical events which once took place here? 'You take away our old tale of the peace of Donald and Severus,' say the burghers of Falkirk. 'I tell you, on the other hand, and it is a good compensation, that many ages before the Romans dwelt at Camelon, in your neighbourhood (if they ever did so), the line of your High Street was a sea-beach, with tides ebbing towards the Carron-works. Hawley encamped on this beach, little thinking of the physical geography of his encampment. Cargill pronounced the excommunication of Charles II. upon it, never once dreaming of alluvia, or of ancient deltas, in the agony of that terrible time. Proud Edward's power advanced over it to fight Bruce at Bannockburn. Wallace hid himself in a tree which had taken root in it, and whose age, though it lived to 1790, was yet at the last as only an hour in comparison with the epoch of the laying down of this ground. Even to the Romans, who looked from their lonely stations on the wall of Antonine over this great plateau, its origin was as much an affair of remote antiquity as it is to us. Grieve not, then, for the loss of an old wives' fable.'"

157. I must here refer to Mr Milne's paper on the Roads of Lochaber, for some particulars regarding certain parallel mounds or ridges which appear in Camelon Park and its neighbourhood. The most northerly, which Mr Milne describes as 110 feet

above the sea, appears to be an outlying fragment of the same beach as that on which Falkirk is built. In the gravel-pits opened in it, are found "boulders three or four times the size of a man's head;" and among these are "blocks of greenstone and porphyry, rocks which occur *in situ* many miles distant to the westward [that is, in the direction of the sources of the Carron]." The next ridge to the south "begins in the middle of Callendar Park, and runs nearly to Linlithgow, a distance of eight miles. The Edinburgh and Glasgow Railway is formed for some distance on the top of it." If so, it must be 211 feet above the sea, thus corresponding to one of the most conspicuous of the ancient beaches. Mr Milne speaks of the most northern, called Redding Ridge, as nearly 300 feet above the sea. These ridges, the generic name of which in Scotland is kames, are ancient beaches of the nature of *spits*, that is, sand-banks corresponding with the sea-level, and parallel to lines of coast, with lagoons or narrow sea-channels intervening.

158. Accordant with Mr Milne's observation as to boulders, is one made by the writer of the article on Larbert parish in the *New Statistical Account of Scotland*. Speaking of the alluvial deposit, as it exists in that district, he mentions that a few boulders are found, "most of them belonging to the trap formation, fragments probably of the rocks of the

adjacent Kilsyth Hills, in which hills the Carron has its source."

159. The Carse of Stirling has already been described in the opening of this chapter. I now design briefly to allude to memorials of higher sea-rests which exist in that district.

160. The valley of the Forth is composed at Stirling of the broad flooring of the Carse, through which the river pursues its curiously sinuous course, and of hills which rise more or less abruptly, and generally with rocky faces, by its sides, but to no great elevation. In the bays (so to speak) formed by the wavy line of these hill-faces, there are fragments of gravelly plains considerably elevated above the general base of the valley—remnants of ancient alluvia which have manifestly been saved by their entanglement amidst the juttings and windings of the valley walls.

161. One of these is seen to the south of the isolated hill on which Stirling is built, the race-ground being a part of it. It is a small plain of from 106 to 117 feet above the level of the sea, seen at a quarry opening to be composed of stratified sand and gravel to the depth of seventy feet! From its elevation, it evidently is a memorial of the same sea which laid down the terrace at Falkirk.

162. On the opposite side of the valley, there is a similar plain extending for a couple of miles to the eastward of the opening of the side-valley of the Allan, abutting in that direction against the steep

face of the Abbey Craig, backed by the Demyat and and Airthrey hills, and coming to a steep bank on the side towards the Carse. It also extends to the westward of the Allan valley, every where composed of gravel and stratified sand. This plateau is 165 feet above the level of the sea, thus coinciding with a marking already spoken of as existing in many places. In its centre, at Airthrey Well, is a longitudinal swelling or mound about fifteen feet higher—an ancient sand-bank, the greater part of which would be elevated above the waves, at the time when the plain was formed. On the front, again, near the Abbey Craig, there is a small fragment of a lower terrace, stated by Mr Maclaren to be from 57 to 67 feet; and a similar fragment exists on the opposite side of the valley.*

163. Four or five miles to the south of Stirling on the Falkirk road, there is a plain corresponding in elevation to that at Airthrey, and abutting like it against a range of rocky cliffs (trap).

164. Thus there are, in the district of Falkirk and Stirling, examples of ancient beaches at 43 (Carse), 67, 90, 117, 165, and 211 feet.

### VALE OF THE TWEED.

165. The Tweed, descending from the Peebles-

* A minute account of the terraces described in the above paragraph is given by Mr Charles Maclaren, *Jameson's Journal*, October 1846.

shire hills into the wide vale of the Merse, and joining the sea at Berwick, has a course of about a hundred miles, during only eight of which does the tide affect it.

166. The general frame of the land is such as to prevent the Tweed from terminating, like the Tay and Forth, in an estuary. It continues elevated down the sea-side, where it has bold terminations, while the river runs in a deep trough with comparatively narrow banks. The flatness of the elevated land near the river is remarkable; this and the clayey nature of the soil are what have given the Merse that eminence which it enjoys as an agricultural district. Yet it is not all on one flat. When carefully examined, this district is found to be composed of at least three distinct floors and the intermediate shelving-ground. The lowest is that which forms the terrace-like banks of the river. The highest forms a sort of rim of country, extending all round except to the east, and backed by the hills. The intermediate flat or flats are less conspicuous. At Horncliff, on the English side, this rim of country struck me forcibly; the pretty Gothic church of Ladykirk is seated upon it. At Paxton, I made measurements from the tide-line in the river up to the front of the lower terrace, and found it to be the same height with the corresponding objects in the valleys of Forth and Tay, and at Inverness—96 feet. Inland it rises to about 114. Traced down towards

Berwick, we find it become still more terrace-like. Broken for a short space by the opening of the side-valley of the Whitadder, it is resumed beyond at its proper level. The site of the ancient castle of Berwick, now the terminus of the North British Railway, is its last appearance on that side of the river.

167. From the general form of the land, sea-markings of less elevation are rare in this district, but not unknown. In the trough of the river, on the south side, about half a mile above Berwick bridge, a flat appears at from 30 to 32 feet. This is repeated at Tweedhill on the opposite bank. At Gainslaw is a flat at 44 feet; opposite to Finchie, another at 55 or 56; opposite Paxton, one at 58. These measurements* correspond in a remarkable degree with others given for terraces in different parts of the country. At Eyemouth, the 44-feet terrace appears near the sea; likewise one at from 64 to 70 feet. On a prominent fragment of the latter, Mary de Guise erected her well-known fort, with a view to maintain the Catholic religion and French policy in Scotland.

168. Passing over several miles of intermediate country, we shall look into the Tweed valley at Kelso. The surface of the river is here 83 feet above the sea. The country to the eastward is open

* From Mr Milne's paper on the Parallel Roads of Lochaber. I have, however, seen and measured several of these elevated haughs, as they may be called.

and broad; to the west it contracts, but without rising into any considerable heights. All who have been at Kelso will remember the smooth flatness of the ground on which the town is built, and which stretches far to the eastward. This is about 108 feet above the sea-level. It is the inland termination of the terrace seen at Paxton and other places, and whose opposite extremity is at Berwick castle. Strictly speaking, it extends more than a mile further west, into the park of the Duke of Roxburgh. Behind Kelso, scarcely out of the limits of the suburbs, the ground rises about 14 feet, and then occurs another flat, here of little breadth, and probably corresponding with some of those intermediate ones seen near Paxton. Then there is a steep and comparatively high cliff, faced and crowned with wood, being the frontier or escarpment of a third flat of considerable extent, on which the race-ground is situated. This is from 60 to 70 feet above the Kelso flat, just about the interval which I found between the Paxton terrace and the rim of country seen at Horncliff. I have, therefore, no doubt that it is the continuation of that plateau. On the opposite side of the river, within the grounds of Springwood Park, a cliff, surmounted by a flat of similar level, is seen. Thus, there are at Kelso three distinct ancient sea-beaches; one for which a medium rather than extreme elevation of 108 feet may be assigned, another at about 122 feet, a third at 170. The whole are

presented in a remarkable way to view in the Duke of Roxburghe's park; Fleurs Castle itself being finely seated on the front of the uppermost, its base

ANCIENT SEA-BEACHES AT FLEURS CASTLE.

169.7 feet above high-water at Berwick, while the two lower figure in the pleasure-grounds below.

169. Opposite Fleurs, the Teviot gives its waters to the Tweed, after pursuing for half a mile a course only divided from the principal stream by a narrow but lofty ridge of gravelly and detrital matter, on which are perched the ruins of Roxburgh Castle, so famed in the Border wars. The site of Roxburgh rises exactly to the same height as the Fleurs terrace on the one side, and the grounds of Springwood Park on the other: it is in fact a fragment of the same plateau, fashioned into its strange ridgy shape by the intersections of the two rivers. To one conversant in any degree with this subject, the whole tale is told by a glance of the eye—more correctly, it may be

safely said, than the history of the castle has been narrated in books. A wondrous tale, unwotted of by the Plantagenets' officers who held this old fortress, the Douglas who took it, or the king who undignifiedly lost his life in levelling cannon against it:—contrary to all wont, the most ancient history the least fabulous.

170. At Melrose, a few miles farther up the river, the valley is broad and open, with the side vales of Leader, Allen, and Gala branching from it: on one side the triple-topped Eildon Hill rising to 1381 * feet, on the other the lower and flatter Gattonside Hills; the intermediate low grounds chiefly of gravelly character. In this beautiful district sits the old abbey of Melrose. On the right bank of the Tweed, a few miles to the west, is the dream-like castle of the Border Minstrel. The active manufacturing village of Galashiels nestles in the mouth of one of the branch vales.

171. The river being here 270 feet above the sea, we have none of those terraces at inferior heights which figure so conspicuously in the lower part of the valley. There is no difficulty, however, in tracing higher sea-markings. A terrace at 346 feet is seen on the borders of the low gravelly plain near the

* Ascertained by levelling from the railway at the bridge in Dingleton Street, Melrose (328′ 2″ above the 18-feet mark on the dock-gates at Leith). The previous statements of the height of the highest summit of the Eildons are from 10 to 20 feet wrong.

junction of the Tweed and Gala. It may be traced from behind the villa of Lowood to Abbotsford, which is situated upon it. A much more prominent terrace at 391-3 feet extends along both the Tweed and Gala. It affords a site to the church and old town of Galashiels, and forms part of the park adjoining to Gala House. Here it is ascertained to be composed of well-rounded pebbles and sand, the latter in some places disposed in thin laminations, and curiously distorted. Stumps or hummocks of the same terrace pass along the woods connected with Abbotsford: some of them are seen closely bordering on the Selkirk road; others appear in the Faldonside pleasure-grounds. Standing at Boldside,

TERRACES ON THE TWEED, NEAR BOLDSIDE.

and looking up the Tweed vale, we see this terrace on each side near the bridge, as delineated in the accompanying sketch. If traced up the Ettrick, we find it terminating in Carterhaugh and Philiphaugh.

This is a sea-marking which we have already seen in Lochaber, and in Lothian. It evidences a long-enduring pause of the sea, such perhaps as that of our own era.

172. At Galashiels, there is a terrace on the hill-face above the village. Flat spaces of the same elevation are seen on hill-sides in the neighbourhood; long flat pieces of the sky-line, several miles down the valley, come to the same level. On one of the hill-side flats of this height, a portion of the town of Selkirk is built. In these particulars we have the local memorials of an ancient level of the sea at about 542-5 feet. Between the Meigle and Rink Hills, near Galashiels, there is a long flat land-strait or *col* of the same elevation. A few miles up the Tweed, a terrace of this height is seen at various places, particularly at Elibank, Ashiesteil, and Caddon-lee. It can be traced into the side-vallies of the Leithen and Quair, and all along to Peebles, a little above which it is lost in the rise of the valley. This town is situated on a plateau of gravel, which fills up the mouth of the side-vale of the Eddlestone Water, excepting the hollow which is carved out by that stream in pursuing its way to join the Tweed. The main streets of what is called the new town, and the upper part of the old town, together with the ancient church of St Andrew and the Cross church and monastery of Red Friars, are seated on entire portions of this plain, which is

542-5 feet above the level of the sea. The plain, in its original entire form, filling up the opening of the Eddlestone valley, and projecting a little way into the Tweed vale, was simply the delta of the Eddlestone Water in the era of the 545-feet sea, the accumulation of detritus which it brought down from the mountains and delivered into the estuary then filling the vale of Tweed to a point a little above Peebles.

173. Two terraces intermediate to the two last, namely, at 442-8, and at 497 feet, can be traced more faintly at various places throughout this district. The first is seen on the skirt of the Eildon, overhanging the rill which passes behind Melrose—also at the Kiln-knowe in Gala vale, where a deep section for the Hawick Railway shows it to be composed of a bed of pure sand.

174. This district is remarkable for the diligence with which a local inquirer has observed and traced out certain markings on the hill-faces, of the same nature with those already alluded to as visible on the Lomond and Tarvit Hills in Fife. Mr Kemp began his investigations eight or nine years ago, and has carefully explored every part of the country for several miles around his residence at Galashiels. Being accustomed to the use of the spirit-level, as well as competent to take heights by surveying, he has not only been able to trace the markings on from one point to another, but to test their parallelism, by observing their respective elevations at dif-

ferent places. I have thought it right to examine these appearances. A friend has also gone over them deliberately, and supplied some good general descriptions. Perhaps I may thus be able to give a tolerably correct account of them.

175. Starting with the Eildon Hills, reference may be made to the accompanying sketch, for certain horizontal tracings which may be observed on

MARKINGS ON EILDON HILLS.

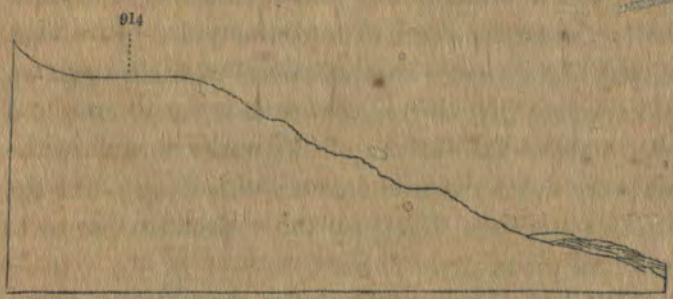
their front towards the north-west, and also for certain step-like prominences which appear upon the profile of both hills towards the right. When these are closely examined, they are found to be produced by flats of greater or less breadth extending horizontally along the hills, generally observing a slight declination outwards. Falling far short of the Glen Roy terraces in continuity, they fully match these celebrated markings in point of breadth; but they are less smooth and regular, for which a reason might

be found in their being rather of the nature of lines of erosion in the rocky material of the hills, than a mere indentation in an alluvial facing, as the Lochaber Roads are, though many of them are also of this character, or at least composed of detrital matter. One is at first disposed to suspect that structure is the cause of the appearances; but this idea becomes untenable when we observe that the arrangement of the rocks is utterly different from that of the terraces.* One might then surmise that the markings are wholly casual; but this, again, appears inadmissible, when we ascertain, by the use of the spirit-level, the coincidence of one marking with another, throughout the range of hills within view, embracing a sweep of not less than five miles. The average interval between the markings being above fifty feet, it can hardly be supposed that there is any vagueness in the case, allowing of one marking being brought into relation with another not strictly corresponding to it.

176. What, again, is very striking, is the various character of some of the markings which stand in harmony with each other. For example, on reaching a terrace which appears at two places on the face of the Eildons at 829 feet, we find that we are precisely on a level with the linear top of the Gatton-

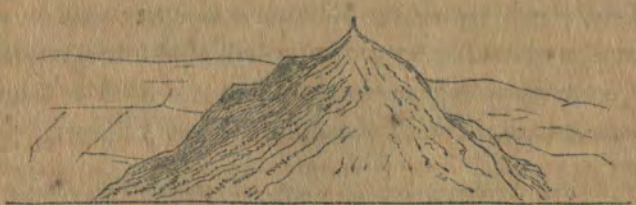
* "The rocks of which they [the Eildon Hills] consist, are felspar and felspar porphyry." "Clinkstone appears in many places." Clay slate and grawacke are the principal rocks composing the other hills of the district.—*Stat. Acc. passim.*

side Hills opposite, and the extensive moorish table-land which stretches thence by the farm of House-byres across to Lauderdale—the country traversed by the road anciently used by the Melrose monks when they went to Lauder. At the same height appears a marking, as of the relics of a delta, on both sides of the vale of Allan. On a similar Eildon terrace, at 914 feet, we are precisely at the apparent level of a broad flat, projecting from the face of the Cauld-




SHELF ON CAULDSHIELS HILL.

shiels Hill to the westward; with the level fixed on the same spot, but turned to the east, we take up an object of the same class, but specifically different, namely, the lower of two remarkable notches which



NOTCHES ON PROFILE OF THE BLACK HILL, COWDENKNOWES.

appear in the profile (near the summit) of the Black Hill of Cowdenknowes, about three miles distant.

177. Setting out from the recognised phenomena of sea-worn cliffs, it is not difficult to suppose these markings to have been made by the sea when it stood at their respective levels. Their being impressed in one place and not in another may be owing to peculiarities in the rock, to the energy of currents running in particular directions; in some cases, to the undermining and abstraction of detrital matter, when the sea had sunk to a point below that of the deposition. In the case of a table-land, we can suppose that the original surface was uneven and partly above the surface of the waves, and that the sea wore down the prominences with its saw-like lip, at the same time filling up the depressions, so as to leave all plain.

178. I shall now particularize the terraces, giving them in the descending order originally assumed by Mr Kemp.

179. 1. A shelf near the top of the middle Eildon, marked also on the eastern summit, 1336 feet above the sea. "Meigle Hill, to the south-west of Galashiels, nearly equals the Eildons in height; and on it, round a central rocky crown, a shelf is distinctly marked, corresponding perfectly, when the level is taken by instruments, with those on the two Eildons." *

* So runs the description of a friend, who published his remarks in *Chambers's Journal*, Old Series, No. 444.

180. No. 2—1282 feet—is particularly well marked on the west front of the east Eildon. On the west and north sides of Meigle Hill, it is also visible, the northern front presenting a plain 300 feet in diameter in some places. A marking at the same height appears near the summit of Williamlaw, a remarkable hill in the vale of Gala.

181. No. 3—1226 feet—is well marked on the middle Eildon; less distinctly on the east hill. It likewise appears in the shape of a plain of greater or less breadth on two sides of Meigle and on the south and north of Williamlaw. Mr Kemp has likewise detected this terrace at Inverleithen, a few miles farther up the Tweed.

182. No. 4—1196 feet. This is slightly marked on Williamlaw Hill, and more decidedly on Meigle. Certain long-backed ridges, seen from Williamlaw, are truncated down to this height.

183. No. 5—is marked on the hills around Inverleithen at about 1166 feet. It is slight upon the Eildons, but distinct upon Meigle and Williamlaw; at, however, a few feet higher; a difference probably attributable to the different consistency of the materials,—lines of erosion always tending to be somewhat higher than alluvial flats or terraces, for which the causes may not be very difficult to suppose.

184. No. 6—1133 feet—"At this level," says Mr

Kemp, "a very great mass on the south side of the eastern Eildon, has been swept down and planed, forming a beautiful shelf of about three and a half acres, with the rock rising bare and precipitous above; upon the north side both of the same hill and the middle one, the same shelf is distinctly defined, and about 160 feet in breadth. (See sketch, where this terrace may be distinguished as very near to the level of the saddle between the two hills.) It is also well marked on Meigle and Williamlaw." Mr Kemp afterwards detected it at Inverleithen. This may be regarded as one of the chief markings in the district.

185. No. 7—1087·3 feet—well seen on Meigle and Williamlaw.

186. No. 8—1024 feet. This terrace appears on the Eildons, but more distinctly on Meigle and Williamlaw, on the former of which it is 120 feet broad in some parts. The uppermost shelf on Cauldshiels Hill is conformable.

187. No. 9—967 feet. This appears on the Eildons, Meigle, and Williamlaw. It forms the second shelf on Cauldshiels Hill, and the upper notch on the Black Hill of Cowdenknowes.

188. No. 10—914 feet—marked on the Eildons, and forming the lower shelf of the Black Hill of Cowdenknowes, and the lowest and broadest on Cauldshiels Hill.

189. No. 11—872-5 feet—marked on the hills north of Galashiels.

190. No. 12—829 feet. This is perhaps the chief marking of the whole district. "It was that," says Mr Kemp, "which first attracted my attention. The Eildon Hills assume their conical form immediately above this shelf, which is about 300 feet broad around nearly the whole of their northern sides, and slopes gently downwards. It is the highest of a series on Galashiels Hill, and forms around the north-eastern summit of that eminence a fine level plain 110 feet broad. On the south-east side of Buckholm Hill, it has the appearance of a perfectly horizontal road for a long way round the height. On the west side of the same hill, on Williamlaw, and on others, it appears very distinctly, varying in breadth from a slight trace up to 300 feet." Along the sides of the Tweed, as also of its tributaries the Gala, Ettrick, and Cadon, Mr Kemp traced this terrace. Its conformity with the tableland above the Gattonside Hills has already been adverted to. Mr Kemp remarks that the sea seems so long to have swept round the hills at this level as to wash down their sides to a great extent, carrying away the traces of the superior beach.

191. No. 13. A flat at Lilliard's Edge; markings on hills near Galashiels; 787 feet.

192. No. 14—708 feet. A terrace on Eildon

Hills; foot of the green field at the Calf Hill, a shoulder of the same.

193. No. 15—Ancrum Moss, and great flat at Lilliard's farm; also markings on the Earlstoun Hills in Lauderdale; 675 feet.

194. No. 16—628 feet. A shelf along the Tweed, Ettrick, and Gala; also on the Earlstoun Hills. Flat projections at this elevation arrest attention on both sides of the Tweed valley at Peebles; seen particularly at places called the Kirk-lands and the Loaning-dales; likewise the projecting bank on which Horsburgh Castle is built. It may, like the rest, be marked elsewhere throughout the valley, but has only been examined in those places. It is remarkable, however, that the broad passage or *col* between the Tweed and Clyde at Biggar, much of the basis of which is occupied by a moss, is given as 628 feet above the sea. When the sea stood at this height, the two estuaries of Clyde and Tweed joined in a shallow sound at Biggar, and the southern province of Scotland formed two islands, or rather groups of islands.

195. The next lowest terrace in the Eildon district is that already described as 542-5 feet above the sea. Thus are these high markings connected in an unbroken series with the lower ancient beaches which are so much more generally found, and of whose character, it is presumed, there is so little room to doubt.

196. In all the branch vales of the Tweed, ancient sea-markings are more or less conspicuous. There are some of a very prominent character in the upper part of Lauderdale, in the form of broad terraces or flats projecting from sides of the valley, and about 800 or 900 feet above the sea. In the valley of Ettrick, we have seen that the great plains styled Carterhaugh and Philiphaugh, are simply the deposits made at the head of a particular branch of the Tweed estuary, when the sea stood at the 393-feet level, so often alluded to. Some portions of the town of Selkirk are upon the 542-5-feet terrace overlooking the Ettrick. Opposite to it, a little farther up, and overlooking Philiphaugh, is a gravel terrace, intersected by the Philip Burn, and partly covered by the Hairhead-wood. Philiphaugh below and the Hairhead-wood above, form the scene of the disastrous defeat of Montrose by General Leslie, in September 1645—according to the old ballad:

> "On Philiphaugh a fray began,
> At Hairhead-wood it ended."
>
> *Border Minstrelsy.*

This gravel terrace of the Hairhead-wood is another specimen of the 542-5-feet beach. It is curious thus to introduce a new set of associations respecting a district hitherto so differently regarded. Those who have heretofore looked on Carterhaugh with romantic interest, as the scene of the fine fairy ballad of

Tamlene,* and rambled over Philiphaugh with melancholy reflections on the final blow given to the cause of King Charles, on the very day when his Queen was singing the *Te Deum* in Notre Dame for a series of hopeful victories, may now see in these places the memorials of natural transactions, placed far, indeed, in the cold regions of an earlier past, but infinitely grander than any doings of men, natural or supernatural.

197. Passing into the subordinate vale of Yarrow, we find that this last terrace continues for a long way to be very conspicuous on both sides. At Broadmeadows, and above the village of Yarrowford, it can be traced through the woods as a remarkable feature of the ground near the base of the hills. On the opposite side, a broad promontory composed of it advances into the centre of the valley, and on the fore-point sits the grand old border fastness of Newark, so celebrated in ballad lore—

> "There's a fair castelle, bigg'd wi' lime and stane,
> Oh! gin it stands not pleasantlie!"
>
> *Song of the Outlaw Murray.*

Or who can ever forget—

---

* "O I forbid ye, maidens a',
That wear gowd on your hair,
To come or gae by Carterhaugh,
For young Tamlene is there."

*Border Minstrelsy*, ii. 187.

"The way was long, the wind was cold,
The minstrel was infirm and old;
His withered cheek and tresses gray
Seemed to have known a better day;
The harp, his sole remaining joy,
Was carried by an orphan boy. * * *
He passed where Newark's stately tower
Looks out from Yarrow's birchen bower:
The minstrel gazed with wistful eye,
No humbler resting-place was nigh. * * *
The Duchess marked his weary pace," &c.

*Lay of the Last Minstrel.*

It is only following up the remark on last page, to say that historical and even poetical matters often have their basis in geology. The situation of Newark was sure to commend itself to such persons as the outlaw Murray and the early barons of the Buccleuch family, since not only it is fenced on more than one side by the steep bank at the bottom of which brawls the deep and rapid stream, but it affords a view both up and down the vale, so that nothing could pass unobserved. These natural circumstances are all traceable back to one condition originally,—namely that an alluvial sheet of matter should have been deposited here, when the sea was 545 feet above its present level,—to be afterwards carved into steep sinuous banks by the Yarrow, when the sea had retreated down the vale.

198. A few miles farther up the valley, there is an opening, or comparatively wide space, in the midst of which stands the simple church of this pas-

toral region, together with a farm-house and mill. In various directions around, are seen those minor recesses which are alluded to in the beautiful old legendary poetry of the district as the *Dowie dens of Yarrow*:—

> "As he gaed up the Tennies bank,
> I wot he gaed wi' sorrow,
> Till down in a den he spied nine armed men,
> On the dowie houms of Yarrow."

One feels it as almost a pity to disturb the hallowed associations of the scenery with any reference to natural facts; yet here are some objects which, in the present inquiry, it would be wrong to overlook. Opposite to the church, a terrace hangs on the unclothed skirts of Deuchar Swire, facing towards the river. From rough measurements it appears that a sea at 656 feet would cover this terrace. Looking up the glen, we see another terrace extending westwards from behind the farmhouse, and intersected by the stream. This would in like manner be submerged by a sea at about 709 feet. Turning now our attention to the "den" at Kershope, we see that one of the slopes is clothed with alluvium of a fertile character up to a certain point, where it terminates in a horizontal line, above which moor begins—a marking similar to one in Glen Goinach at Kingussie (§ 86). This I made 825 feet above the sea. All of

these markings, then, are roughly relative to others in different parts of the country.

199. Standing on Deuchar Swire, and observing the opposite hill, exactly above the mill, we discover a series of projections having rocky cliffs below, and green flats above, horizontal, yet slightly declining at each end, and amounting to at least five. This form cannot depend in any degree on structure, for the grawacke strata are here nearly vertical, with a strike almost rectangularly contrary to these lines. Three terraces of apparently an alluvial character appear on the less steep hill-face to the east, corresponding in level to the three uppermost of these Deuchar markings. There is also a hill on the right side of the vale, directly opposite to the last mentioned objects, the upper part of which, bearing the name of Blackandro, presents a notched profile exactly like the Black Hill of Cowdenknowes as seen from the Eildons. These notches also correspond in level with the uppermost of the Deuchar terraces. The five heights involved in this assemblage of markings, along with some others of greater elevation, have been taken in the manner of a levelling survey, by an amateur, and thus reported:—

1276. Eighth and highest terrace on Deuchar hill.

1186. Seventh do., corresponding with the top of the pass of Kershope Swire, where the road passes over into Ettrick.

1126. Sixth do.

1081. Fifth do., well marked on Fast-heugh Hope, a hill to the south.

958. Fourth do.; probably corresponds with a terrace on Aldinhope hill, a little farther up the valley,—set down as 961.

879. Third do. [By another measurement, 875.] Terrace on Aldinhope hill at same height.

824. Terrace on Aldinhope hill. [Corresponds with line of changed vegetation in Kershope.]

779. Second terrace on Deuchar hill. A level tract at this height runs up the valley to the Gordon Arms public-house.

685. First do. [By another measurement, 687.] Broad alluvial flats skirting the Yarrow at this height.

630. Alluvial terrace at Deuchar Mill.

## BASIN OF THE CLYDE.

200. At a certain early stage in these local researches, they had as yet been limited to the east side of the island. Uniformity had been ascertained from one side of the Firth of Forth to the other; and this seemed a step of some consequence. There remained, however, the more important question—Were the two sides of the island alike? Were there memorials of sea-rests in the vale of Clyde, coincident with those in the vale of Tweed? If so, it was almost equally a matter of curiosity to discover the points in the present vale to which the estuary ex-

tended, at the respective times when certain points in the Tweed vale were at the head of the ancient Tweed estuary.

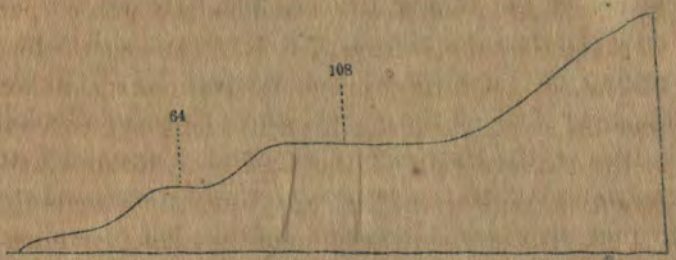
201. Examining the outer parts of the Firth of Clyde first,—that is, about Greenock and Gourock,—I found such slight and obscure markings on those bold shores, as made me for some time afraid that the above questions could never be answered. Passing, however, to the isle of Bute, I at length found a response not to be mistaken. Three miles or so to the south of Rothsay, is Ascog House, seated upon a fine terrace sloping seaward, and terminating in a steep bank, below which is a low narrow plain along which the road proceeds. This terrace stretches a considerable way in both directions. The resemblance to a great plateau, already seen in many places towards the German Ocean, was striking. To acquire assurance of its true identity, it was only necessary to measure its height above the sea. Finding that at half an arrow-flight from the front of the terrace, I came to sixty-four feet,—the height most characteristic of the beach above mentioned,—I felt that the first great fact had been secured towards the conclusion that the entire island was in one predicament with regard to changes of the relative level of sea and land.

202. Such other parts of Bute, as I examined, did not prove fruitful of observations. The island is intersected by two valleys from side to side, the extre-

mity of one being the site of the chief town, Rothsay. At the back of this town, there is a piece of perfectly flat ground filling the entire space between the hills, as the bottom of a box occupies the whole space between the sides,—from 27 to 32 feet above the level of the sea. On the front of it, overlooking a short seaward slope which the town has long ago covered, is the massive ruin of the Castle of Rothsay, the favourite residence of the early Stuart monarchs.

203. The other intersection of the island, commencing at Port Bannatyne, terminates on the opposite side in Ettrick Bay. On the hill-face, to the west of the bay, a second example of the beach represented at Ascog, was traceable at the proper height above the sea. The alluvium of which it had been originally composed, and which perhaps would spread out a hundred yards from the hill, had been, by the action of the sea at a subsequent level, worn down to a mere crust, which the untutored eye would have regarded as only a slight swell or bank, speaking of nothing. Precisely similar objects in other situations, adjoining to, and harmonising with, unequivocal terraces, had prepared me to apprehend the true character and history of this prominence, which others would have passed over without notice. Here was proof of uniformity respecting both sides of Bute, and a second evidence for that of the island of Great Britain. The conclusion to which the facts tended was materially helped, when, on measuring up the

heights a little farther, I found at Ettrick farm-house, and some way behind it, a decided terrace at 108 feet. Here, too, was a specimen of what I then

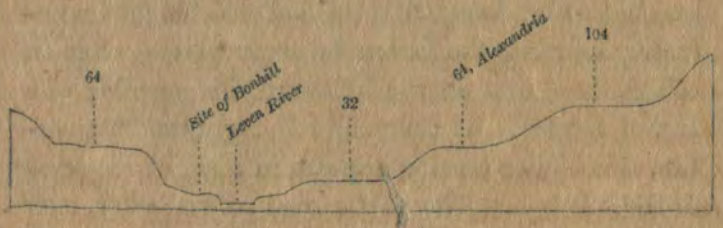



TERRACES AT ETTRICK BAY, ISLE OF BUTE.

considered as the second great beach, and at precisely the suitable height.

204. The vale of the Leven, leaving that of the Clyde at a right angle, would of course be the seat of a comparatively quiet branch of the ancient estuary. Broader markings were therefore to be expected in it. On examining the space (about five miles) which intervenes between the Clyde and the bottom of Loch Lomond, I found it a flat region, composed for the most part of an alluvium about 30 feet above the sea, but with a haugh of a third of that height immediately skirting the Leven in many places, while in others there rose on the hill-ward side snatches of a higher terrace. At Dalreoch toll-bar, near Dumbarton, this higher terrace appears in a slight recession of the hill face. The public road passes below, over the 32-feet alluvium, which perseveres till we reach

the village of Renton, where the monument of Smollett is placed upon it. At Alexandria, another village farther on, we have ascended to a pretty broad example of the higher terrace, and here we see not only the two low alluvia, but a terrace still higher resting on the slope of the adjacent hill. On the opposite side of the valley, the village of Bonhill nestles on the river side, close under a steep cliff, at the top of which is a terrace precisely corresponding to that on which Alexandria is built, but extending to a much larger superficies—indeed, passing on with hardly any interruption to the bottom of the lake. Now, the terrace at Alexandria, and behind Bonhill, is of the same height as that at Ascog. It became, in my investigation, the third great fact inferring uniformity for the two sides of the island. Moreover, the higher terrace at Alexandria being about 40 feet above the lower, proved to be the same which I had ascertained in the lower part of the vale of the Tweed, and of which a fragment had more recently appeared at Ettrick Bay. A section of the Leven




SECTION OF VALE OF LEVEN, DUMBARTONSHIRE.

vale at Alexandria exhibits all these terraces in a sufficient clear light.

205. At Glasgow the river has ceased to be an estuary, though affected by the tides for three miles higher, namely, to Rutherglen. Around, and also within the city, I have found several of the ancient beaches. In Glasgow Green, the same two haughs which occupy so much of the Leven vale, are distinctly seen; one of them about 11, and the other 26 feet above the ordinary level of the sea. The Trongate and adjacent districts of the city are built on the second of these plateaux, which also extends over a large space on the opposite side of the river. At Partick, to the west of the city, this beach is also clearly marked, being there about 26 feet high.

206. The Ascog beach likewise appears in and near Glasgow, but does not pass through it so uninterruptedly. Ascending from Partick towards the

SECTION OF ANCIENT BEACHES, WESTERN SUBURBS OF GLASGOW.

Observatory, we find it at Dowanhill, and also on the east side of the Kelvin valley. If we make a cross

movement from the river bank at the Broomielaw, the following ancient beaches will be found:—First, the street of Broomielaw, a piece of ancient haugh, 10 feet above high water-mark; Second, another flat at Anderston Street, at about 30 feet; Third, a terrace sloping up to the skirts of Garnet Hill, somewhat irregular, but exhibiting some entire pieces (for example, the site of *Free St Matthew's Church*) and attaining an extreme height of somewhat more than 80 feet. A similar cross movement in the eastern suburbs, starting at the Green, and passing up to the lodge of the House of Refuge, gives a precise repetition of these gradations. The Hill Street Factory is there seated upon the 64-70-feet level. In the central part of the city, we pass at once from the 26-feet alluvium (for example, at George's Square) up a steep slope, to an irregular height not less than 100 feet, remarkable for a capping of diluvium containing a number of far-transported boulders. But in the line of the High Street, the University Buildings clearly sit upon the same terrace which we find at Dowanhill and the Hill Street Factory. On the right bank of the Molindinar Burn, opposite to the Craig Park, there is a fine piece of terrace, about 150 yards in length, and perhaps fifty feet above the tiny stream. This is (approximately) 144 feet above the sea.

207. In the autumn of 1847, the workmen

engaged in enlarging the harbour of Glasgow at Springfield, opposite the Broomielaw, discovered an ancient canoe deep imbedded in the soil, at the distance of about a hundred feet from the margin of the Clyde. From particular inquiries, with the results of which I have been favoured, it appears that this relic rested on a bed of gravel fifteen inches thick, covering a bed of finely laminated sand. Over it was a bed of loam, nine or ten feet thick, surmounted by sand: the entire depth of the situation of the canoe below the surface was seventeen feet, being just about the level of low water in the river. It also appears that the distance of the situation from the river's brink was less by a third than it was in years not long bypast, as the Clyde has latterly been much widened in this quarter for the benefit of the navigation.

208. Mr Robert Stuart, in a recent work, entitled "Views and Notices of Glasgow in Former Times," gives a drawing of the canoe. He describes it as formed from a single piece of timber (oak), measuring rather more than eleven feet in length, twenty-seven inches in breadth, and, where the sides are in best preservation, about fifteen in depth. The fore part is almost entire; but at the opposite extremity the sides are somewhat broken down. Here there is a groove extending across the bottom, which leads to a supposition that this end of the tree had been cut away, and that a separate piece of wood had been

fitted into the groove mentioned, so as to form a stern.*

209. On a narrow inspection of the ground where the canoe was discovered, I have found that the sand-bed on which the relic reposed dips towards the river, and that the overlying loam presents laminations in the same direction. It appeared to me that the deposit of gravel over the sand was probably the last event of the time antecedent to the assumption of its present level by the sea; that the boat had been immediately after laid down, and that the loam was a succession of deposits since made by floods in the river, which is known occasionally, though rarely, to rise 15 feet above height of spring tides. This hypothesis takes the deposition of the Springfield boat out of the range of geological history, but still assigns it a very remote antiquity and a date of no small interest.

210. It appears that the discovery is not a solitary event. In July 1825, while some workmen were digging a sewer in London Street, near the Cross of Glasgow, they found their progress, at the depth of nine feet below the surface, impeded by some hard substance, which proved to be a boat,

* In the work entitled "Old England," is a drawing of a canoe found in 1834 in a creek of the river Arun, near North Stoke, Sussex. It has a vertical stern with radiated markings, probably a similar arrangement to that here described. This boat is stated in the Gentleman's Magazine to have been 34½ feet long, 4½ broad, and 2 deep.

lying in a vertical position, with the prow uppermost. In the account given of this discovery in the Gentleman's Magazine, it is stated that the boat lay "in a bed of blue clay, which was covered and surrounded by fine sand, like that found on the shores of a navigable river or wide firth." A local writer says it was computed to be eighteen feet long, and that in the inside there were sand and shells.* The Gentleman's Magazine says, that "some of the nails which were used as fastenings, were in the wood, which was of fine oak, become quite black from its long immersion under the earth." The same chronicler adds—"The calking used for the boat appeared to have been wool dipped in tar." No ribs were used in its construction. The site of this boat is in the centre of Glasgow, and it had long been covered by a building called the Trades' Lands. I regret to add, that, after the upper part of the vessel had been broken into pieces, and dispersed among curiosity-hunters, the remainder was left in its original situation, and soon after covered over by the new buildings of London Street.

211. In the account given in the Gentleman's Magazine, it is stated that, some years before, when the common sewer was cutting in the Stockwell, a boat of a singular description was found a little

* "Glasgow Delineated." Glasgow, 1826.

above Jackson Street. As yet I have obtained no authentication of this statement; but there seems no reason to doubt that, when the foundation of the Tontine Buildings was in the course of being dug, in 1781, a similar boat was discovered, "imbedded in sand and gravel, several feet below the surface."* Thus at least two ancient boats, besides that at Springfield, have been discovered under the surface of the ground at Glasgow. The number is remarkable, when we connect the remote era to which they seem to point with the modern distinction of the district as a seat of commerce; seeming to indicate that, even in the earliest ages of the inhabitation of our island by man, there had been some unusual amount of intercourse by means of navigation in this region.

212. The situation of the boats found under the Tontine and Trades' Lands (places within a pistol-shot of each other) is 21 or 22 feet above high-water in the river. It forms part of that extensive plain which rises from the river's brink to the height of about 26 feet above tide-mark, forming the site of the Trongate and Argyle Street, and the numerous streets to the north and south of that line. This plain is composed of sand, as appears whenever the foundation of an old house is dug up. Mr John Craig, an able practical geologist at Glasgow, says,

* Chapman's Picture of Glasgow, 1818, p. 152.

in a communication to one of my correspondents—"The deposit immediately underlying the Trongate and London Street is a bed of sand, with traces of lamination; this rests on laminated clays, the same as occur at the brickworks at Annfield, east end of the Gallowgate, and on the other side of the river. These clays abound in several places in recent marine shells. They are deposited on the boulder till."

213. If the sand-bed at the Trongate be the same with that at Springfield, the boats lying in it and the subjacent clay obviously belong to an earlier period than that discovered in the latter situation. The question arises, are the deposits such as the river, while pursuing in general its present level, could have laid down? The situation, be it remembered, is a quarter of a mile from the river; its superficies is 21 feet above tide-mark, while Mr Robert Stevenson has determined the greatest recorded river floods as only 15. The laminated sands do not, moreover, appear such a deposit as a river flood would bring to the spot, even if it could reach it. It therefore appears that we scarcely have an alternative to the supposition, that, when these vessels foundered, and were deposited where in modern times they have been found, the Firth of Clyde was a sea several miles wide at Glasgow, covering the site of the lower districts of the city, and receiving the waters of the river not lower than Bothwell Bridge. We must suppose this to

have been a time when already a people instructed to some degree in the arts of life, occupied that part of the island. Taken in connexion with the whales' bones and perforated deers' horns of the Carse of Stirling, the boat and other relics said to have been found near Falkirk, the human skull at Grangemouth, and the various particulars already cited with respect to the Carse of Gowrie,* these Glasgow canoes are objects of much greater interest than any one seems yet to have thought of attaching to them. Mr Smith of Jordanhill has pointed out† that the Roman wall, at its terminations on the Firths of Forth and Clyde, appears to have been formed with respect to the present relative level of sea and land. He also quotes the description of St Michael's Mount in Cornwall, which Diodorus Siculus gives in the time of Augustus, showing it to have been then as now connected with the mainland at ebb tide. Thus it appears that any change of level must have taken place before the earlier days of our historic era. If so, these relics must be assigned to an age still more remote. Perhaps it may yet appear that even the era of the Roman invasion makes but a small ap-

* In Sympson's History of Galloway, written in 1684, there is an account of the finding of a ship deeply imbedded in the earth, below a watercourse at the town of Stranraer. "The boards were not joined together after the present fashion, and it had nails of copper."—*Transactions Scot. Ant. Society*, iii. 52.

† Ed. New Phil. Jour. Oct. 1838.

proach in retrogression to the age when these vessels floated with their human freight on the waters of the Clyde.

214. In the vale of the Clyde at Glasgow, there is a range of hills of no great elevation on each side, and the space between these is several miles. Between the low alluvial plains and the hills, on either side of the river, there is a range of low heights, generally oblong in the line of the valley, of rounded outline, and capped thickly with the diluvial clay. Garnet Hill, Gilmour Hill, and the eminence on which the Observatory is situated, are the chief eminences of this kind on the right bank. A greater number variegate the country around Pollockshaws, on the left bank, insomuch as to give a peculiar character to the district, each eminence usually bearing the suburban retreat of one of the wealthy merchants of the western capital. All these rise to one height, namely, about 182 feet above the level of the sea. But there is one called Camps Hill, flat-topped, and apparently about ten feet higher. The whole are probably the remnants of an ancient alluvial plain or sea-beach, corresponding with those found in several places at 192 feet above the sea. Flat-topped examples may be considered as possessing their original surface, rounded ones as having had theirs partially worn off.

215. If we leave Glasgow by the eastern suburbs in order to proceed up the valley of the Clyde, we

pass over broken and irregular portions of the 64-75-feet beach for several miles. The village of Tolcross is upon an entire portion; and at the villas of Thorn, Dalbeth, and Easterhill, we find its cliff presented steeply above the river. The Gorbals, and other districts of the city to the south of the Clyde, are upon the comparatively low alluvia, which are continued for several miles southward. If we proceed up the valley on that side of the river, we find no higher ground till we approach the ancient burgh of Rutherglen, nearly opposite to the villas above enumerated. Here, behind a low haugh of fine rich land, rises a steep gravelly bank, which, when we ascend to the top, we find to be surmounted by a perfectly flat terrace, of sandy constitution, on which the town is fairly seated, without any perceptible change of level, excepting at the west end, where there is a scooped-out water-course. This terrace at its front is exactly 64 feet above high-water in the river. It is, from arrangement and relation, one of the most satisfactory specimens of the terrace found at that level which has come under my attention. To the eastward of the town, as to the west, there is a hollow, but the true level is resumed at a villa called Gallowflat, and it is seen passing on for a great distance along that side of the valley. There are appearances of higher plateaux behind Rutherglen, but they have undergone much scooping, which has transformed them into long ridge-like hillocks, with equally long deep chan-

nels between, all in the direction of the line of the valley.

216. Reverting to the right bank—we pass on from Tollcross for several miles over ground generally near the Rutherglen level, but bearing many knolls, which are the relics of a higher plateau: one very striking, crowned with a tuft of firs, overlooks the road about half a mile from the Clyde Iron Works. At Calder Bridge, we come in view of what appears as a kind of barrier across the vale, one or two miles onward—sharply cliffed, flat-topped, and presenting on its frontier the village of Uddingston, as a former terrace had presented the burgh of Rutherglen. My rude measurement made the fore parts of this terrace from 122 to 128 feet above the sea. It is found to be of great extent, passing on in one unbroken stretch of perfectly flat ground to the mansion of Bothwell Park, which frontiers and looks down from a similar cliff on the other side upon the wide-sweeping alluvia of Bothwellhaugh and Hamilton. It is thus describable as a great *bracket*, advancing from the north side of the vale, and coming at Bothwell Castle to a steep cliff or bank overhanging the river—the *Bothwell Bank*, so celebrated for its beauty, and embalmed in our national poetry. The country opposite being of similar height, I conclude that a large mass of this beach had been left stretching unbroken across the valley, and that the sea at the lower levels had only been able, with the

aid of the river, to hollow out the narrow channel which the Clyde now possesses, and form the great alluvia beyond, on one of which Hamilton Palace is built. Bothwell village and church are involved in the space of ground occupied by this beach; but they stand upon a kind of swell or knoll rising out of it—probably the relics of a higher plateau. When the Duke of Monmouth brought his army against the unhappy Presbyterians at Bothwell Bridge, he looked down upon them from the cliff of this beach, and it was from its summit that his artillery wrought such deadly destruction in their ranks.

217. A large portion of the centre of Lanarkshire may be described as an elevated plateau of the old red sandstone and superior formations, seamed profoundly by the channels of the Clyde and its tributaries, and crowned with diluvium, sand, and gravel. Hills of considerable elevation are seen only at a distance on either hand. In the hollows made by the streams there are rugged cliffs, steep banks, and magnificent waterfalls; but, in the portion which I examined, no trace of the former presence of the sea. When we ascend to the surface of the plateau, the memorials of that element become extremely striking and impressive. The parishes of Lanark and Carstairs may be taken as a specimen of the whole. The plateau is there composed of a deep bed of sand and gravel, consisting of prominent portions of large extent (Lee Moor and Lanark Moor), which are flat-

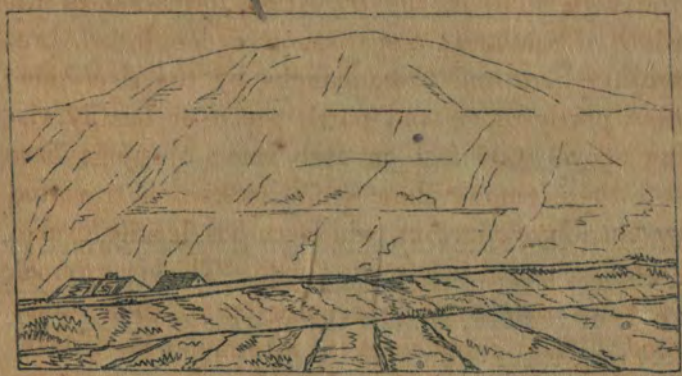
tened like a bowling-green, with intermediate hollows of little depth, usually containing peat moss. The road from Lanark to Biggar crosses over one of these flat tracts, which has been converted into a race-course, and the village of Renstruther stands upon another, a hollow interval of fully a mile being interposed. Cranley Moss, through which the Mouse water creeps for a long way before entering its rocky chasm, is another portion of the same plain. These masses form cumulatively a gentle slope, rising from about 675 feet at the race-course to 680 at Renstruther, but reaching 687 in some detached portions at Carstairs village, which had apparently formed the inland limit of this beach. Altogether, it is a grand example of such objects, and the interest attending it is not a little increased when we find it conforming in elevation with Ancrum Moss in Roxburghshire, (§ 193), with a terrace in Borthwick parish, and a delta in Glenspean. The larger stones are chiefly of old red sandstone, but partly of primitive rocks brought from a distance. Between Carstairs and Carnwath it is backed by a range of sand hills, the remnants of higher plains, but amongst which I could only distinguish one appearance of uniform heights, at 728 or 730 feet.

218. The uppermost parishes of the vale of Clyde were at a later period selected as a field of investigation, in consideration of the convenient basis for levels supplied in that quarter by the Caledonian

Railway. We have here the usual appearances of the high vales in the transitional formation of the south of Scotland; a space more or less broad, presenting here and there haughs by the river-side; hills, partly rough and partly green or heathy, rising above 1000 feet on each side; openings here and there among these eminences, each traversed by a tributary stream, which rushes hastily over a gravelly channel to join the Clyde. The low grounds are cultivated, but above Lamington are thinly inhabited. The railway comes to its summit level, 1000 feet above the sea, at the *col* dividing the valley from that of the Dumfriesshire Evan.

219. At Wood-end, in Lamington parish, a steep rough hill rises on the right side of the valley, along which it is possible to trace two patchy horizontal markings, formed by flat-topped projecting masses of the rock, the upper being by far the most continuous. The accompanying drawing gives some idea of the appearances. The upper line is continued in a different kind of marking into the hollow or bosom of the hills to the north. It is ascertained, by a professional survey, to be 278 feet above a point of the Caledonian Railway, which is 739 feet above datum, or 721 above the sea. If this estimate of the elevation of the rails is correct, the height of the terrace above the sea is 999 feet. A higher line, not represented in the drawing, is set down by the same authority as 1139 feet above the sea. In the

opposite direction, that is, from a higher point in the



TERRACES ON HILL AT WOOD-END, LANARKSHIRE.

valley, we see the profile of this hill marked by the 999-feet terrace in a striking manner. There, too, be-

tween Wood-end and Middle-gill, there is a recess in the hill-range, where several horizontal lines are presented, sometimes mound-like, sometimes produced by a change in the vegetation. In the following little

sketch of a group of these lines, the central one is about

820 feet above the sea, while the uppermost, formed by a change from grass to heath, is 872. Towards the angle of the hill, besides the markings of the 999-feet line, there is another at about 1025.

220. Each of the tributary streams has its broken delta of gravel at the mouth of its own little glen. That of Glengonar water supplies a curious illustration of our subject. It has been originally extended across the chief vale, almost to the hills on the other side. Between its extremity and these hills, only a narrow gap has been left, through which the railway now passes. On the withdrawal of the sea-arm from this part of the vale, the river had pierced through the skirts of the delta, leaving a small portion isolated as a mount between the parent glen and the opposite hills. This is simply a repetition of the phenomena already described with regard to the delta of the Bran at Dunkeld. The delta of Glengonar water was formed in the sea which stood somewhere between 820 and 830 above the present level. The village of Abington is situated upon it. These Clydesdale deltas are the more remarkable,

as the skirts of the valley present scarcely any gravel-banks or terraces elsewhere.

221. At Crawford, the valley expands into a considerable plain. The branch vales of Midlock and Camps waters here open into it, and the skirts of the hills have every where a *hem* of ancient alluvium overlooking the modern haughs by the water-sides. One of these relics, under the site of the village, is 826 feet above the sea. A prominent mass on the right bank of the Clyde, near the ancient castle, and which is composed of clay and gravel distinctly stratified in many places, is of unequal surface, but generally a little higher than the last terrace.

222. Several of the hill-faces around Crawford are seamed with horizontal lines, which, on a near examination, are found to be terraces, carved in the superficial bed of semi-alluvial debris, many paces broad, and which are the more remarkable as they are repeated from one hill to another. The accompanying sketch represents the principal group, as

TERRACES AT CRAWFORD, LANARKSHIRE.

seen from the village, with the old castle in the foreground. The heights have been ascertained for me by a professional survey, and are stated at 937, 1023, 1090, 1107, 1171, 1204, 1251, 1286, and 1362. The fourth of these numbers is the height of two flat-topped hills on the opposite side of the valley, between the Camps and Midlock waters, and on the side of the valley above Crawford village, there are terraces which I set down from my own measurements at 938 and 995. Other terraces on the same side, measured by the surveyor, are 844, 910, and 962. This gentleman informs me that he observed the whole first series of markings at corresponding levels on a third hill-face to the westward of the other two; but, whether from less favourable light or any other cause, I failed, on two visits to the district, to detect these appearances.

223. At Newton or Elvan-foot, there is a similar opening, where the side-vales of the Daer and Elvan join the principal valley. In these lateral vales, but particularly the latter, there are low broad alluvial plateaux, one of them sufficiently definite to appear as likely to lead us to a true former level of the sea. It appeared as 912 feet, being very near one of the Eildon markings. A strong flat line produced by a higher ancient alluvium at the base of the hill in the angle between the Elvan and Clyde, is 963 feet. A mile up the Elvan glen, we catch a projecting mass of alluvium of striking appearance, being the

delta of a side-burn; its elevation was noted down as about 1025 feet. On the soft-faced hills round about, there are many horizontal lines, of the same character with those of Crawford, but too slightly marked to furnish very solid ground for speculation. Some of the more prominent can nevertheless be traced from one hill to another as perfectly coincident in level, and the subject may be worthy of further investigation.

224. Thus, it appears that the central mountain-range of Southern Scotland, from which the Tweed and Clyde take their almost contiguous origin, bears marks of ancient sea-levels at coincident heights on both sides. The Annan, too, harmonizes; for, in its branch vale containing the Evan water, I found a marking of far from doubtful character at 1023, besides another at 1073 feet. The former is a large hummock above the junction of the Harthope water with the Evan, being the wing of the ancient delta of the tributary stream. The latter is a faint line seen in various directions around Straight-step Bridge. Three or four miles above Beatock, there is a grand hummock or bracket starting from the angle between the Cloffin water and Evan, perfectly flat-topped, and having the farmhouse of Middle-gill seated upon it: this is a remarkable object in the history of the investigation, being the first example found in this country of a sea-marking at the height of 576 feet from the sea.

### ANCIENT DELTA OF THE RIBBLE.

225. Considering how much of the island lies to the south of these Scottish vales, I felt the necessity, before any general conclusions could be arrived at, of ascertaining the elevation of such ancient sea-margins as were to be found in England. Here, indeed, there was already some reason to expect similar markings, as far as the general elevation of the land admitted; for patches of a beach about 60 feet high had been described by Professor Sedgwick and Sir Roderick Murchison, as traceable at Barnstaple Bay on the north coast of Devonshire, while a terrace of similar height had been traced by Mr Austen along the banks of the Exe; and another patch had been observed by the same gentleman, at the same elevation, at Hope's Nose, beside Torbay. Still there had been no such research for these objects in England as had now been instituted in Scotland, and I therefore resolved to consider nothing as having yet been done for a general conclusion respecting the island, till it should have been examined at several points on the west and south, with the same rigour which had been exercised on the northern coasts.

226. The Ribble in Lancashire—a much larger and more powerful river than is perhaps generally supposed—debouches from the mountains at a dis-

tance of ten or twelve miles from the sea. The intervening space, partially hemmed in on either hand by high grounds, is occupied by a vast sloping plain of red clay and gravel, through which the river passes by a deep intersection, having in general very steep sides. The upper part of this plain, at Longridge, is about 300 feet above the sea; and Sir Roderick Murchison has stated that, amidst the sands, marls, and gravels found in beds at that height, shells of existing species have been detected.

227. This great inclined plain is simply the ancient deposit of the river—the accumulation of materials brought by it into its ancient estuary, when the sea stood more than 300 feet above its present level. On the change of level taking place, this deposit was presented as a plain, and the river began to cut a channel through it by which to reach the receded sea. It is exactly such a formation as the Pampas is with respect to the Rio de la Plata, though only perhaps on a scale of one mile to a hundred. The formations in the Highland vales, which have here been recognised as deltas, are objects of the same class, though with some specific differences referring to situation.

228. The town of Preston sits upon a flat space towards the lower extremities of this plain, on the right bank of the river, and from 120 to 128 feet above the mark of tide at the bridge. The ground is clearly the same beach as that marked near Both-

well, though not so well defined in its features as we find it in some other instances. South from the town, on the way to the bridge, we find also a tolerably distinct flat at 100 feet, being no doubt the next lower terrace. If we walk, again, from the western suburbs—that is, in the direction of the slope of the formation—we speedily make a somewhat abrupt descent, and find ourselves on another extensive plain, comparatively, if not perfectly flat, and from 60 to 70 feet above the sea. It is very distinct at Ashton Chapel.

229. Leaving Preston in the opposite direction—that is, against the rise of the plain—it is just possible to trace near the Jail a slight rise, which is all we have in the way of superior escarpment for the 120-8-feet beach in this quarter. From this point to Longridge (7 miles) there is a gentle slope, in which I failed to detect any appearance of indentation. In the neighbourhood of a place called Redscar, where I estimated the surface of the plain at 170 feet above the sea, I looked narrowly for a trace of higher beaches, but no such marking could be discovered. It was not till after a similar disappointment in Ireland, that a reason occurred to me why there is a more than usual chance against indentations being made in such formations. As already remarked, a certain boldness of inclination seems necessary on the part of the land, in order that the sea may exercise its mordant power. When the

slope is extremely gentle, the water will quietly rise and fall upon it, and make comparatively little impression. As the rise between Preston and Longridge is probably not above 24 feet per mile, we can see that it was ill fitted to receive such a stamp, although in the lower and steeper parts of this great talus the sea had left memorials of at least three pauses made by it at subsequent intervals.

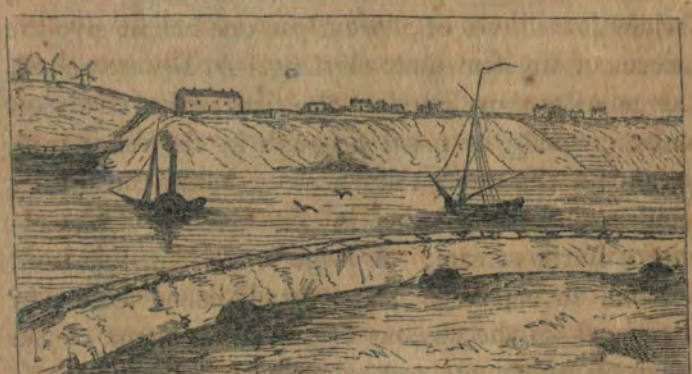
230. The deep valley pervading this ancient delta is itself a remarkably interesting object. Varying from half a mile to a mile in width, it presents sides which in many places are almost as steep as walls, while flat alluvia of more than one height give the river a more immediate skirting. At Redscar, about three miles above Preston, the river makes an abrupt curve, leaving as usual a haugh in the inner part, while on the outer rises a steep bank, continually undergoing dilapidation in consequence of the attacks of the stream. A large landslip in this bank —such an object as is universally called a *scaur* in Scotland—is the obvious origin of the name of the mansion which sits somewhat insecurely above.

### THE MERSEY.

231. The estuary of the Mersey is, near its junction with the outer sea, bounded on both sides by rising grounds of gentle elevation. This was the

first valley or estuarial basin which I had had an opportunity of examining in England, and it was therefore examined with no small interest. The north-west suburbs of Liverpool extend over a great flat of equable surface, permeated by a wide street called the Vauxhall Road, and having several narrow streets descending by a gentle slope towards the docks. This flat is from 60 to 70 feet above the sea.

232. When from the quay walks at this point we look right across the Mersey, we see a long extending cliff rising abruptly from the sea-side, with the



TERRACE ON THE MERSEY AT SEACOMBE.

villages of Seacombe and Egremont perched on the top, and partly along the face (§ 25). The fore edge of this cliff is from 60 to 70 feet high. The terrace behind, rising in a gentle slope inland to somewhat more than 85 feet, but not quite equably—as if the original longitudinal line of the beach were somewhat

angular in regard to the present coast-line—obviously is a repetition of the form of ground we have seen at Granton and at Glasgow. Near Egremont Chapel a new rise commences, and half a mile onward, at the village of Liskard, a second flat is found at the height of 101 feet. Here were undoubted markings of two of the Scottish terraces.

233. Let us now shift the scene of investigation to the south-east outskirts of Liverpool, near the termination of the line of docks in that direction. Here the ground rises somewhat abruptly, broken by quarries and works, but attaining at top an appearance of flatness, and there beginning to be occupied with the streets of the fast increasing town. The height at this point was evidently more than that of the cliff at Egremont; there was no appearance of a pause in its slope, excepting at the narrow flat space over which the road proceeds, and which is about 20 feet above the sea. On measuring up along the face, I found, at 64 feet, a slight narrow platform, which the cutting at a quarry showed me to be composed of a bench of sandstone, covered with a coating of debris two feet thick. Mounting up along the rough ground, through which the bare rock frequently projects, I found the flat at the top to be 128 feet—the very height of the beach near Bothwell. It extends at about this height a great way on both hands, as well as inland; in which last direction there are some grounds a little higher. It is simply,

like the platform a little lower down, a bench of sandstone with a thin covering of soil.

234. From Toxteth Park, as this district is called, I distinctly observed a terrace-like formation of the ground on the part of the coast directly opposite, being the district adjoining to Birkenhead on the south-east. One of the lines appeared, by the level, to correspond precisely with the Toxteth terrace on which I stood. On a close examination, this proved to be the case; and the lower terrace also appeared there of the proper height, as it had previously done at Egremont.

235. The fact is, that the principal parts of the town of Birkenhead, including Hamilton Square, are built on a sandstone bench between 60 and 70 feet above the sea, to which it stoops by a steep cliff, like that at Egremont, while behind it the hills rise like the back of a chair to the Toxteth height. At Rock Ferry, two miles farther up the river, where the general rise of the land is greater, we find, instead of a sandstone bench, a clayey flat at a low inclination, from 54 to 75 feet above the sea; and behind this, at Tranmere, we come to a sandstone terrace at 128 feet, from which the spirit-level takes up flat sky-lines alike to the north-west and south-east, as well as the Toxteth flat on the opposite side of the Mersey. In short, the sandstone in this district being of a soft consistence, the edge of the sea has first shaved down the general mass to 128 feet

above the present level, leaving, however, at some places, a small portion of the work unfinished (the slight backing at Toxteth and Tranmere); and then, while resting at a relative level about one-half less elevated above the present, it has carved out a broad bench for the site of Birkenhead on one side of the estuary, and formed the little platform at the quarry on the other. Another circumstance calls for particular remark: While the beach is at Birkenhead a close-shaven rock, it is at Rock Lane composed of a thick bed of clay reposing on rock. In the one instance, from the opposition presented by the comparatively bold ground, a fierce cutting power has been exercised: in the other, from the circumstances being wholly different, the water brought clay, which it quietly deposited up to the height at which itself then stood;—a cutting down of rock in the one case, a filling up with clay in the other. Owing, moreover, to the gentleness of the ground at Rock Lane, a lower beach seems to have run into and blended with the upper.

### CHESTER.

236. The site of Chester, and the country for many miles around, form a very slightly varied plain of new red sandstone, in which a deep narrow cut has been formed for the course of the Dee, here

about to pour itself into the Irish Sea. Towards the north, the ground on which the city is situated rises considerably above the general level, and a tower is there placed from which Charles I. surveyed the defeat of his army on the neighbouring moor. In general, however, the character of this district is flatness.

237. The elevation of the surface above the ordinary height of tides in the Dee is from 60 to 72 feet. The crossing of the two principal streets in the centre of the town is 69 feet; the base of the cathedral 72. The prominence on which the castle stands, immediately over the Dee, is a little lower. In short, the whole plateau is only a larger example of the phenomenon at Birkenhead—a bench carved out of the soft sandstone by the sea when its surface at high tide was a little more than 70 feet above its present level.

### BRISTOL.

238. This ancient city lies on the banks of the Avon, a few miles from its junction with the Severn. With heights rising on every side, the city seems placed in the bottom of a basin; but there is, in reality, a good deal of low ground about its outskirts. Rather more than a mile below the city, the river leaves the basin, vanishing through a deep abrupt

cut in the limestone heights, close to the finely-placed suburb of Clifton.

239. Standing at Bristol, we see all around it a *rim* of hills several hundred feet in elevation, within the range of which the eye readily detects a *rim* of lower heights, which, in reality, are the edges of shelves or terraces that start out from the hills. Standing on the rising grounds to the north of the city (a place called the Park), we can see on the opposite

TERRACES AT BRISTOL.

side of the valley, at a particular place, a second set of such shelves at a lower level. The great set coincides in elevation with the top of a conical mount called the Castle Hill, which rises between Bristol and Clifton; it also comes up to Clifton, where a range of buildings (called, if I am not mistaken, the Royal York Terrace) is placed upon it; then, lost at the gap through which the river passes, it is

resumed beyond, in a great rocky but irregular plateau called Clifton Downs.

240. From high-water-mark in the river, the day after highest spring tide (February 18, 1847), these downs appeared at a height of from 261 to 266 feet. Here the level at about that height took up a distant portion of the great *rim* or shelf which has been alluded to. The summit of the Castle Hill appears to be only a few feet lower, being probably a somewhat worn down, outlying mass of the same great terrace. This elevation is very remarkable, for as 16 feet must be allowed for the abnormal height of tide in the Avon (making 277-82 in all), the terrace would appear as of the same height with *a beach* found in many parts of Scotland. It was of course to be expected that there should be nothing abnormal in the tides of this district when the sea stood at a higher level, as it would not then move in the narrow channel to which it is now sunk, and which has the effect of raising the surface to such an unusual height.

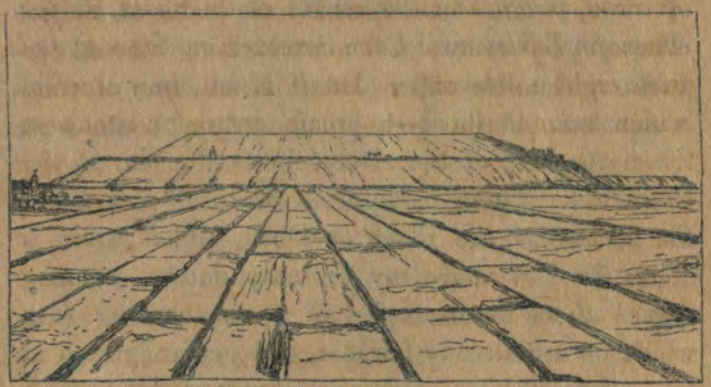
241. The lower set of shelves is seen very distinctly in passing along the road to Wells, a little before coming to Knowle Chapel. They present clay and other alluvial matters reposing on the almost horizontal beds of the limestone. By a somewhat rough calculation which happened to be alone attainable in the case, I made the height range between 187 and 193 feet above the ordinary high water of the outer sea. This nearly corresponds with one of the

most broadly marked of the terraces in other districts.

242. In the comparatively low grounds in and around the city, there are several flats at such an elevation above the high water of the river, as suits the requirements of a well known Scottish beach. One of these spaces is in the centre of the town, at the junction of Wine and Corn Streets; on the verge of another, the celebrated church of St Mary Redcliff is situated. A third—a broad terrace or bench on the north side of the river—forms the site of the Cathedral. These being from 36 to 43 feet above the surface of the Float or Dock, which again is about 12 feet above my ordinary datum, we may regard them as examples of a sea-marking with which we are already familiar, one generally seen at from 53 to 56 feet. Other fragments of this plateau appear about Bedminster, closely adjacent to Bristol —one at Roanham-Field, near Cleft House, another on the road at Ashton Court Lodge.

243. Passing from Bristol to the coast of the Bristol Channel, we enter at ten miles from the city upon an extensive plain, which rises from the seashore at so gentle an inclination, that, as already mentioned (§ 8), the Bristol and Exeter Railway, passing over it for 28 miles, rises only four feet throughout the whole of that distance,—a rise doubtless owing to the line crossing obliquely up the slope. Weston-super-Mare is a bathing village situated on

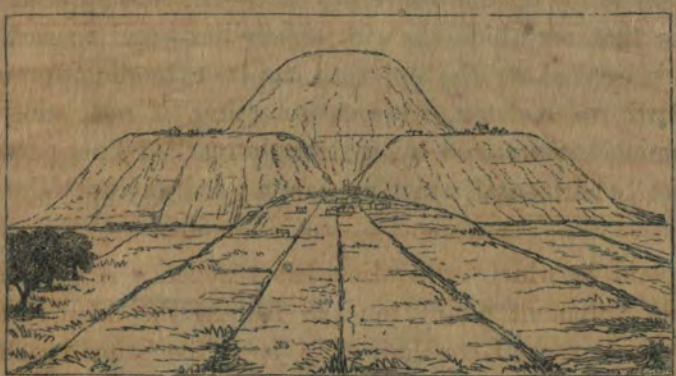
the coast at the bottom of this great inclined plain, about 20 miles from Bristol. Here, however, start up two mountains, one at each side of the village, and one of them almost insulated by the sea. Weston hill, to the right, is a long flat-topped ridge, with a rude terrace presented from the side, the highest



TERRACEDHILL AT WESTON-SUPER-MARE.

point to which cultivation has reached. A careful measurement giving me 128 feet as the height of this terrace, I conclude that it is the same beach with that near Bothwell. The summit of this hill, an extensive oblong plain formed of the rock thinly covered with soil, forcibly suggests its having been shaped by the trenchant power of the sea; and this idea is fortified by the measurement—342 feet—which comes very near to the height of a terrace conspicuous on Tweedside, and in other districts. From the inland extremity of the hill, there projects a terrace lower than either of these; but I did not

get an opportunity of measuring it. On Preen-down hill, the peninsulated eminence to the west of the village, there clearly appears all along its side a *crust* or remnant of a terrace; and this I ascertained by the level to be likewise 128 feet above the sea. Thus, it will be observed, the terrace most conspicuous at Weston, is one of those which are blank at Bristol. There is, however, a still more striking alluvial terrace eight miles off, at Brent Knoll, one of those which bound the great plain to the south-west.



BRENT-KNOLL, SOMERSETSHIRE.

From the plain this hill has the appearance of a low and broad truncated cone, with a smaller cone, also truncated, laid on the top in the centre. The lower and broader top is in reality a terrace, with remarkably steep escarpments, surrounding the upper mount, but somewhat cut down at one place, in which the village of Brent nestles with its church. The terrace

coincides in height with those on Westonhill and Preen-down.

## BATH.

244. This city, as is well known, occupies the bottom and steep sides of the valley of the Avon, at a point about ten miles farther inland than Bristol.

245. It is impossible for any one to pass along this valley on the Twiverton side—the side opposite to that on which the city chiefly lies—and to cast his eyes along the opposite slopes, extending from Bath to Kelston, without observing, if not being somewhat arrested by, a strongly marked line, perfectly horizontal, which appears a good way up. The

TERRACE AT BATH.

suburban village of Weston, the mansion-house of the same name, and the large modern building called

Partis College, are presented upon this line, and serve to make it the more conspicuous. On ascending to it, it is found to be a broad terrace extending at a very slight inclination to the face of the hills. At Weston House, which has the hills close behind it, the terrace in front is certainly little less than half a mile in breadth. At Kelston we see it in profile, like the seat of a chair, with the house and its beautiful groves seated upon it. In the contrary direction, we may readily trace it into the mass of the city, where it has furnished a site to the celebrated *Crescent*. My data and measurements assign a height of from 186 to 190 feet to this grand terrace, bringing it into a sufficiently precise relation with ore seen at Bristol and other places. On the opposite side of the valley, no such markings occur at this level; but, near Holloway, are two small and much worn fragments of a terrace, which, from its relation to the above, may be set down as coincident with the terrace on Weston Hill and Brent Knoll.

## LONDON.

246. It can scarcely be necessary to remind any one of the character of the situation of London—a valley of very gently inclined sides, which nowhere rise to any considerable elevation. The river at this point is affected by the tide.

247. On the south side of the Thames, and for many miles in both directions, is an equable alluvium, which in some places can scarcely be said to be elevated above high water. At Deptford, it rises from about 5 to 30 feet above ordinary high water, with no perceptible variation of inclination (§ 15). At London, on the opposite side of the river, between Charing-Cross and the eastern parts of the city, there is no distinct correspondent marking; the rise of the ground from the river is there more bold, and not of the character of an ancient beach, till we arrive at a higher level.

248. A true tidal slope, though here and there slightly irregular, passes from about a line extended between Covent Garden and Golden Square, back to near Camden Town and Paddington. This is the beach so often referred to as terminating at about 90 feet—a fine example of it. It appears also in a beautiful inclined plateau at Walton, on the Southampton Railway; likewise in a great stretch of slightly rising but equable ground behind Deptford.

249. At Brockley, two miles inland from Deptford, there is a great plain at 112 feet; thus coinciding with another of the series. It reappears on the other side of the little valley of Ravensbourn, near Lewisham.

250. But the grand terrace of this district is that extensive flat, composed of chalk debris containing

round pebbles, which, crowning the bank at Greenwich Park, passes on to Blackheath and Sydenham in one direction, and to Dartford, if not farther, in the other, with surprisingly little variation of level. One prevalent height of this terrace is from 145 to 150 feet. It is so at Woolwich as distinctly as at Greenwich, though Shooter's Hill rises between to break the continuity. At one spot, however, on Blackheath, I found it fully 154 feet. Instances of markings, which may be regarded as coincident, occur in the north of Scotland and in Lothian.

### SUSSEX AND HAMPSHIRE.

251. Even after having so far found a uniformity of markings along the coasts of our island, it seemed to me very desirable that some investigations should be made on the south coast. This was not only necessary to settle the question of an entire uniformity, but it promised to lend some light to the kindred question regarding a former connexion between Britain and France.

252. The chalk mountains of Sussex and Hampshire come, as is well known, in some places, near to the sea; in others, they leave a considerable breadth of low plain between them and the English Channel.

253. At Brighton, where they stoop down almost

close to the shore, the remains of a comparatively modern alluvial bed hang upon their skirts, forming the basis of the Marine Parade, and filling up the bottom of a neighbouring valley. This alluvial bed is described by Dr Mantell* as composed of fragments of chalk, embedded in a yellow calcareous paste, within which are also included remains of the ox, deer, horse, and Asiatic elephant, generally more or less water-worn. It is presented in a vertical cliff to the sea, but in its surface forms an equable slope, like that along which a tide might play; and this appears generally at the front to be 64 feet above ordinary high-water-mark on the beach below. The *elephant bed*, as it has been called, answers, in short, to the usual configuration of one of the most familiar of the ancient sea-margins in other parts of the island. It is the more striking, as, in ascending the chalk hills themselves, we can at no point of elevation detect any trace of terraces: all is rounded and smooth.

254. At Lewes, eight miles up the valley of the Ouse from the sea, but where the tide makes itself apparent, the hills rise for the most part abruptly out of the low alluvium beside the river. The town rears itself along the hill-face to the west, making a very picturesque appearance, while the river flows close underneath. From the hills opposite, half a mile above and as much below the town, two low flat promontories start out into the low alluvium:

* Geology of the South-East of England, p. 32.

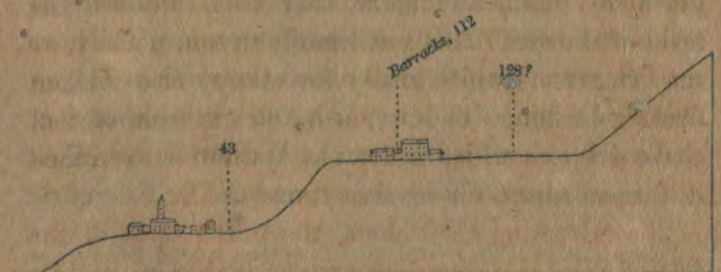
each is found, on near inspection, to comprise a good space of level ground—though that at Malling rises at its outer extremity to a somewhat greater height. These two flats are from 60 to 70 feet above the level of the sea, and doubtless are remnants of an alluvium at that height which the sea laid down when it stood somewhat over the higher of these levels. In the middle of the plain, opposite to the lower promontory at Old Hythe, there is an isolated and flat-topped mount at about the same level. Farther down the valley, there is a similar mount, but at a somewhat greater elevation. These are likewise remnants of ancient alluvial plains, the great bulk of which had been washed out when the sea fell to lower levels.*

255. For thirty miles west of Brighton, the hills recede a good way from the coast-line, forming a *sinus*, the area of which is occupied by a low inclined plain, the most inland part of which I found at one place to be 32, and at another 43 feet above the level of the sea. This great sandy expanse, which we may traverse longitudinally for many miles without the least change of level, is a fine example of that ancient beach which is seen at Weston-super-Mare, and at so many other points round the British coast;

* Care must be taken to distinguish from these natural eminences, an artificial one connected with the ancient priory. It has much the appearance of a remnant of alluvium, like the mounts of Dunipace, and the Bass of Inverury, and the situation is appropriate; but I am assured by Dr Mantell, that it is composed of matters from the valley, including vegetable mould, and in reality was a construction designed by the religious of the place to represent Mount Calvary, and to serve a purpose in their ceremonials.

being the one to which hitherto almost exclusive attention has been given. The city of Chichester is seated at a point near its inland margin.

256. Here, however, we do not at once ascend the round slopes of the chalk. Owing apparently to the protection given by the curving range of the hills, there is at Chichester, and for several miles both east and west, a great terrace or bench of chalk-gravel advancing from half a mile to two miles from the hill-faces, and presenting a pretty steep escarpment towards the great plain below. The London road from Chichester, immediately on leaving the city, commences ascending this grand terrace; and the Barracks are there found seated on its frontier, at about 112 feet above the level of the sea. Thence it rises in a quarter of a mile to 118 feet; but from this point onward to the hills not much less than a mile intervenes, and during that




SECTION OF ALLUVIAL PLAINS AT CHICHESTER.

space there is a further rise of a few feet: probably the beaches usually ending at 117 and 128 feet here

run into each other. The surface is nearly quite as smooth as that of the lower plain. Four or five miles westward, above a place called Chicham, I made another examination of this terrace, and found it to be there from 123 to 128 feet, and similar in its relations to the lower plain, but less regular in its surface, the ground presenting several marshes and meres in the tract nearest to the hills. The whole must be considered as an example of the beach on which the town of Preston is situated, and which appears above Liverpool and Birkenhead, and at Weston and Preen-down, as well as in various places in Scotland.

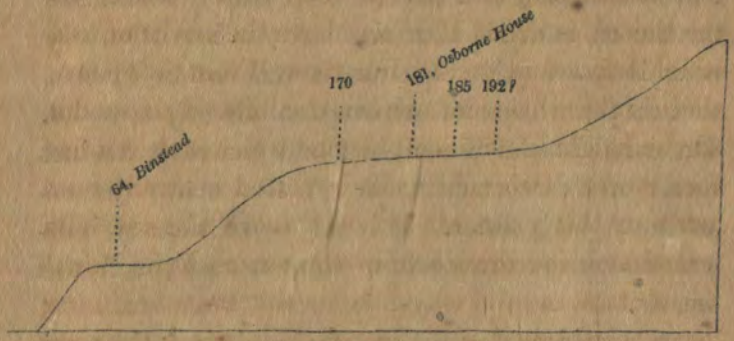
257. On the borders of the Southampton Water, the land assumes in several places a terraced form. Inland from the town, the country also presents numerous instances of such plateaux as have been elsewhere found on measurement to coincide with the more prevalent beaches. I was only able, however; to make one measurement at Southampton, namely, at the flat ground which rises above the river at Itchen floating-bridge. This extensive flat is composed of chalk-gravel, and is, at the place where I examined it, 66 feet above the level of the sea.

258. Crossing the Solent, the north coast of the Isle of Wight is found to present highly interesting appearances. A large tract on that side of the island, extending from Ryde to far beyond Cowes, and se-

veral miles inland, is a terrace of chalk-gravel, here and there intersected by water-courses. The frontier, at the head of a pretty steep slope, looking to the Solent, is about 170 feet above the marks of tide which I found in the Medina river. From that point, there is a gentle ascent towards the hills. I pursued it to the height of 185 feet, beyond which it rises a few feet more. Osborne house is seated centrally on a mass of this plain, at 181 feet above the sea. Its prominent appearance from the sea at Ryde, starting out of the flat sky-line to the westward, must have been remarked by many. This terrace appears to be composed of a fusion of the two ancient sea-margins, here set down at 165-72, and 186-92 feet. This, however, is not all, for, from the front of the terrace behind West Cowes, I found by the level that the opposite coast of the mainland of Hampshire ascends to precisely the same altitude, and perseveres at it for many miles, though rising less abruptly from the shore. We may accordingly infer that this is the corresponding ancient beach of the mainland.

259. The only other results which I had an opportunity of ascertaining in Wight are comparatively trifling. At Newport, lying several miles inland, in the valley of the Medina, my level took up a plateau at about 117 feet; but, being observed from a distance, I cannot speak of it positively. At Binstead, near Ryde, I was able to make a closer inspection of some

terrace appearances there presented in a little valley near the coast. Their height is about 64 feet above




SECTION OF GRAVEL TERRACE, NORTH SIDE OF ISLE OF WIGHT.

the sea, recalling of course one of the most familiar of all these markings.

## DEVONSHIRE.

260. The principal beaches under 200 feet having already been found on the south coast, it seemed only necessary to examine more of that district for the sake of confirmatory evidence, and that I should visit certain markings of this nature which had previously been described.

The valley of the Exe, in the space of a few miles which intervene between Exeter and the sea, was stated by Mr Austen to present a flat expanse of land, high above the present water-level, but which

must have been accumulated under salt or brackish water, as the beds abound with British species of Mactra, Tellina, and Cardium. " I readily found this terrace on both sides of the vale; it is particularly conspicuous at the Barracks, a mile below Exeter, and at the village of Alphington directly opposite. On careful measurement, I found the most distinct parts of this terrace to be 67 feet above the sea at mean high water. It is the beach already indicated as one of the most prevalent around the British coasts.

A considerable portion of the city of Exeter is situated upon a narrow bench of ground presenting a steep escarpment towards the river. In form—abstracting the buildings—this bench precisely resembles that at Blackheath and Greenwich Park. Its fore part is 126 feet above the river, and it ascends perhaps 10 or 15 feet before it graduates into the higher grounds out of the city. The river, however, is here a pool, confined for navigation purposes at 11½ feet above mean high water. The terrace may therefore be taken as at a medium of about 146 feet; thus coinciding in elevation as in form with that at Greenwich, and tallying in the former respect with certain flats seen in more northern districts. The Cathedral near by rests on a flattish piece of ground, 126 feet above mean high water. I attach little importance to the circumstance, as we have here no external feature to guide us; yet the

elevation is remarkable, from its near correspondence with another of the best marked sea-margins.

261. In a large district of the Devonshire coast to the south of Exeter, we find the Old Red Sandstone presenting an alternation of long heights and little valleys rectangularly towards the sea. The heights in some places project into the water, forming such bays as the well known Tor bay. The tops of these promontories are of gently sloping or nearly flat outline. The one which forms the south side of Tor bay, dividing it from the valley of the Dart, has a remarkable appearance from Hope's Nose, the opposing promontory; for its flatness is like that which we should make in a drawing with a ruler, and it perseveres for many miles inland—that is, from the point where it ceases to be the limit of the bay. The

maritime village of Brixham lies in a hollow scooped out of it near the outer extremity. Now, this line, if I can trust to my means of measurement, which, how-

ever, I cannot pronounce to be very applicable to a distant object, is at its more seaward parts from 170 to 180 feet above the sea. It thus appears to correspond in elevation, as in form, to the table land on the north side of the Isle of Wight. The raised beach indicated by Mr Austen at Hope's Nose on the opposite side of the bay, is a piece of that rising from 64 feet, not distinguishable as such from its form, but from its height, its lithological materials, and the fragments of shells found in it.

262. I was much struck by an observation made at Babbicombe, where there is a high abrupt cliff rising directly from the shore, and terminating in an irregular flat, composed of the solid rock. The flatness at this place having awakened curiosity, I resolved to measure the elevation. In my progress upwards, along a steep and rough, but not precipitous acclivity, I was surprised at about 172 feet, to come to a platform-like projection, covered with sand, and clothed with turf. Though too small a fragment to lay much stress upon, it was remarkable, in such a situation, to find it so near one of the points of elevation where such platforms, if existing at all, are to be expected. The general elevation of the great flat above was equally striking —about 278 feet; a terrace height conspicuous in many parts of Scotland, but hitherto not found at any place in England, excepting Bristol.

263. Various raised beaches are indicated in the

Geological Map of England as existing along the more westerly parts of the south coast. A notable one under the Hoe near Plymouth was discovered by the Rev. Richard Hennah, occupying a depression in the face of the limestone cliff, 100 feet wide and 40 deep. The base of this formation is described as 35 feet above the present sea at high water of spring tides; "it runs upward and backward 20 feet, inclining inwards with the slope of the rock, and is covered by 10 feet of gravel; thus making *its entire elevation 65 feet above the present sea-level.* It is composed," adds the describer, "of fragments of rocks of the neighbouring shore, . . . . . a few shells, . . . . . bones and teeth of the elephant, rhinoceros, deer, &c." *

264. A great part of England, chiefly on the east side and in the centre, is too low to present markings of the nature of those here described. Yet there can be no doubt that the lip of the sea in contact with even this low region, would have the effect of smoothing it, and laying it out in plateaux, which would of course be of great extent. In travelling through the country by railway, with tables of the gradients in my hand, I endeavoured to distinguish these broad impressions; and in several instances plains appeared, corresponding in elevation to the principal beaches, while the intervening spaces pre-

* Report Brit. Assoc., 1841.

sented ground which, though it might be flat, was manifestly not of the smoothened linear character of the rest. One specimen of such plateaux occurs on the line of the Great Western Railway, at Hackron Bridge, about 45 miles from Bath. It corresponds with the beach so often alluded to as 280 feet above the sea. A series of flats corresponding to the same level, occurs three or four miles north of Blaeworth on the London and North-Western line; another, at Leighton; and a third, at Pattishall. Indeed, it is remarkable, that out of twelve *level* spaces which occur on that line between London and Birmingham, *ten* are at heights within the scope of the various ancient beaches here described. On the Grand Junction, again, there is at Witmore, a moorish flat of large extent, 10 or 12 feet above the rails, at a point where they are 388.77 feet above low water at Liverpool; thus corresponding very nearly with the terrace already several times indicated at 386, or from that to 393 feet above high water. It therefore appears to me far from unlikely, that the true smooth plains of England are generally a result of the operations of the sea-margin.

## PARIS.

265. The next step in this investigation was one more important than any of the preceding, namely,

to pass to the banks of the Seine, and endeavour to learn whether these changes of level between land and sea, were uniform only with regard to Britain, or had extended to the Continent.

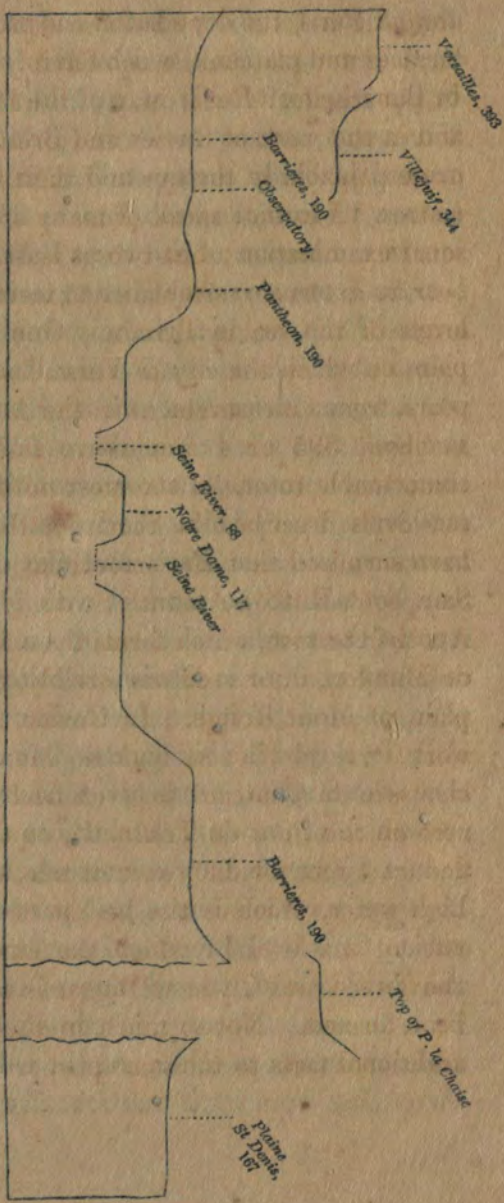
266. The natural character of the surface in and around Paris is soon comprehended. It is simply a basin in the midst of gently ascending hills, of from four to five hundred feet high, permeated by a river here from 80 to 90 feet above the level of the sea. Along both banks of the stream is an extensive alluvium, mainly confined to the site of the city. This, being an unusually wide opening in the valley of the Seine, has perhaps been one of the chief causes of the origin of the city, for it would be apt at all times to attract and concentrate population. It agrees much in general height above the sea with the terraces and plateaux so prevalent in Britain at a mean of 108 feet, but ranging between 96 and 117. Immediately beyond the Boulevards, on the north side of the Seine, and at a briefer distance from the river on the south side, the ground begins to rise; it continues to do so till we arrive at a second flat space at about the line of the Barriers. This is a remarkable *pause* in the ascent of the sides of the valley, and it maintains nearly the same height all round the city. The flat at the Arc de Triomphe is a part of it, which all who have been in Paris must remember. It extends some way within the Barrière St Denis. A comparatively narrow slip appears at the base of the Père la Chaise

cemetery; but at the Barriers de Montreuil and de Vincennes, it expands to a wide plain, stretching towards the village of Charenton. So much for the north side of the Seine. On the south, it is seen at the Barrière d'Italie, and at a place under the Bicêtre, where a quarry shows it composed of fully twenty feet of stratified sand, laid over the rock. A great district frontiered by the Pantheon and Luxembourg is composed of it. It passes beyond the Barrière d'Enfer into what is called the Plaine de Mont Rouge, and so on through half formed suburbs to the Commune de Vaugirard, where it overhangs the low grounds of the Champs de Mars—at one spot, with an escarpment so steep as not to be susceptible of cultivation. Here, having completed the circuit of Paris, we are opposite to the plateau at the Barrière St Marie and the Arc de Triomphe, which appears by the spirit-level to be perfectly correspondent in elevation. The immediate surface of the plateau at Mont Rouge is composed of sand mixed with broken flints. We have one guide to the elevation of this great *ring plain*, as it may be called, in the elevation assigned in the *Annuaire* (1847) to the interior pavement of the Pantheon, 198⅔ feet above mean sea-level. This point tolerably well represents the level of the terrace throughout its large expanse, and shows—when 7 feet are deducted for the difference between mean sea-level and mean high water—that it is just about the same height with one of the grandest of

the British terraces; that found at Brownhills near St Andrews, at Mickleour on the Isla in Perthshire, in the valley of the Ness, at Bath, and other places. The great terrace at Bath (§ 245) is a piece of ground precisely corresponding, in its height above the sea, its form, and relations to the rest of the valley, to the terrace of the Paris Barriers.

267. There are traces of other terraces immediately around Paris, or, as a geologist would describe them, points at which denudation had taken place. The well known *Plaine St Denis* is given by Cuvier and Brongniart at what amounts to 167 feet above the sea at high water, thus corresponding with the terrace immediately below the above. The high ground, therefore, between Paris and the city of St Denis may be said to be marked with the 190-feet terrace on the south, and the 167 on the north. The cemetery of Père la Chaise, starting from the ring-plain, ascends till it terminates in a flat of 315 feet, little developed in this quarter, but corresponding in level with a strongly marked terrace line on the opposite side of the city. A little to the northward, is a plain approached by the streets leading from the Barrière des Amandieres, and partially covered with villas. This is 376 feet, and corresponds with a terrace in Scotland, though one of inferior note, and liable to some difficulty, in consequence of its unusual nearness to another. At the village of Villejuifs, three miles from Paris on the road to Fountainbleau,

there is a terrace of pale reddish earth, overlooking the low plain in which the Marne meets the Seine; this, being 344 feet above the sea, likewise corresponds with a Scottish terrace, though also one of secondary note. The Père la Chaise flat is perhaps related to the esplanade at the Castle hill of Edinburgh; the Villejuifs beach is unequivocally so to the terrace on which Abbotsford is situated.




268. Owing to the horizontality of the strata

around Paris, the denudation has produced many flat terraces and plateaux, which forcibly arrest attention. In Bauerkeller's Relief Map of the Environs of Paris, and in the work of Cuvier and Brongniart, these are made palpable to the eye and their heights given in metres. I cannot speak of many of them from personal examination; but two at least seemed to me to bear an external resemblance to memorials of ancient levels of the sea in Britain. One is the extensive plain on which the city of Versailles is built. It appears, from a measurement in the Annuaire for 1847, as about 393 or 4 feet above tide, and therefore conformable to one of the most noted of the ancient sea-levels described in Scotland, that with which I have surmised that the smoothing of the trough at Sampson's Ribs on Arthur's Seat might be connected. Another terrace, which forms the site of the Château de Meudon, impressed me forcibly, as seen from the plain of Mont Rouge. In Cuvier and Brongniart's work, "le plateau sableux de Meudon, au rez-de-chaussée du Château" is given as 161 metres above zero on the Pont de Tournelle, equivalent, when we deduct 7 feet for difference of tide, to 629′ 6″ above high water, which is the height of that remarkable ancient sea-level by which the land-strait between the Tweed and Clyde at Biggar is presumed to have been formed. Not so much in the hope of finding additional facts to the same purport with the preced-

ing, as to subject the matter to every possible test, I reduced the whole of the measurements I could ascertain from Cuvier and Brongniart, Bauerkeller, and otherwise, into English feet, with an opposite column of ancient British sea-levels: and this is now submitted to the reader. Considering the roughness of a measurement by terms exceeding thirty-nine inches, the results in the borrowed cases seem to me in general to speak much more strongly for conformity than for discrepancy:—

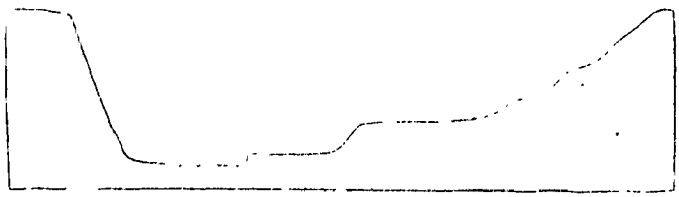
| | | | |
|---|---|---|---|
| Le plateau sableux de Meudon, au rez-de-chaussée du Château (C. & B.) | 629′ | 6″ | 628–30 |
| La sommet de la Montagne de Roquencourt, entre Bailly et Marly (C. & B.) | 600′ | 3″ | 599′ 6″ |
| Near Villeneuve (B.) | 590′ | 1″ | |
| La sommet de la Colline de Sataury [a flat-topped eminence] (C. & B.) | 592′ | 8″ | |
| Near Samois [apparently on side of a height] (B.) | 576′ | 9″ | 573′ 6″ |
| High flat ground in the Forêt de Marly (B.) | 563′ | 10″ | 562′ |
| Do in Bois d'Arcis (B.) | 563′ | 10″ | |
| Versailles—le rez-de-chaussée du Château (C. & B.) | 563′ | 10″ | |
| Near Montigny—Bois de St Mark (B.) | 550′ | 7″ | 542–5 |
| Above Buc (B.) | 547′ | 5″ | |
| [Table land round Rouen | 544′ | 9″] | |
| Villeroi (B.) | 631′ | | 530–4 |
| Near St Cloud (B.) | 508 | | |

| | | |
|---|---|---|
| Sommet du Calcaire, au Mont Ouin (C. & B.) | 465′ 10″ | 463–6 |
| Plateau de Belleville, Romainville, &c. au pied du telegraphe (C. & B.) | 466′ 10″ | |
| Laincourt près Chaumont, sommet du Calcaire (C. & B.) | 422′ 7″ | |
| Plain of the city of Versailles | 393′ | 385–93 |
| Terrace above the Barrière des Amandieres | 376′ | 372′–7 |
| Near Brie (B.) | 350′ 6″ | 342–8 |
| Near Ormeasson (B.) | 347′ | |
| Terrace at Villejuifs | 344′ | |
| Top of Cemetery of Père la Chaise (B.) | 314′ 6″ | |
| St Germain—sommet du plateau (C. & B.) | 307′ 8″ | |
| Near Orley (B.) | 281′ 7″ | 279–93 |
| St Germain (B.) | 268′ 6″ | |
| Plateau de Bois de Vincennes (C. & B.) | 238′ 8″ | 243 |
| Bois de Boulogne, Rond des Victoires (C. & B.) | 191′ 6″ | 186–92 |
| Plain of the Barriers, Paris | 192′ | |
| Plaine St Denis, au Carrefour près de Pantin | 167′ | 165–74 |

### LOWER PART OF THE VALLEY OF THE SEINE.

269. In the railway journey from Paris to Rouen, terraces may be observed skirting the valley all the way, particularly after passing Meulan. On the right side of the river, a little below Vernon, a double range begins. It passes on in perfect parallelism for several miles, stopping at a place called Port Mort,

where the foremost and lowest terrace presents an escarpment down the valley, like a breast-work raised for some purpose in a Titanic system of fortification. I had not an opportunity of making measurements; but from the appearance of the lower, and considering that we are here only a few miles from the place to which the tide reaches, I deem it probable that that terrace is the termination of the plain which skirts the river at Paris. The same terrace reappears on the same side of the river between Meuds and Ande. Generally, as in this case,



SECTION OF BORDERS OF THE SEINE; ON THEIR GENERAL FORM.

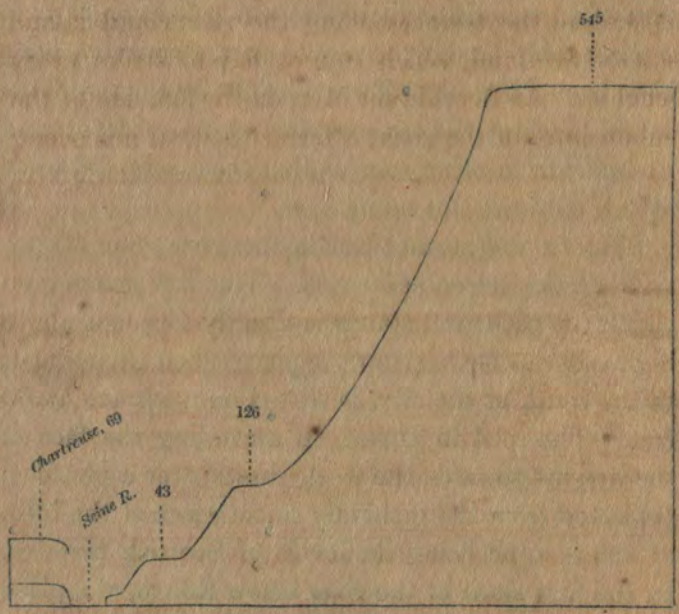
throughout all the lower part of the valley, it is presented on the tongue of sloping land enclosed by the sinuosities of the river; the *outside* of these sinuosities being as generally an abrupt precipice rising at once to the height of the country. This height, I may observe, has a remarkably uniform appearance throughout a large portion of the Lower Department of the Seine. Around Rouen we gain it at 545 feet, and the spirit-level fails to detect any varia-

tion of surface throughout the whole horizon.* It is a chalk table-land, which could only, I conceive, have been brought to so uniform a height by the mechanical force which the sea exercises at its surface; and we know from other sources that the sea-lip did work at this elevation for many ages.

270. In and around Rouen there are some memorials of the lower sea-levels. The flat ground on which the cathedral stands is exactly 42⅔ feet above high water in the harbour. A place called Chartreuse, to the south of the city, is seated on a terrace at 69 feet. The road to Havre, in ascending the face of the heights towards the west, passes over a platform projected from the generally smooth face of the hills, at 126 feet, all being the levels of Scottish terraces. In the first sinus of the river below Rouen, at a place called Val de Haye, the enclosed tongue of land presents an unusually perfect specimen of one of the lower beaches, probably at about 55 feet above the river: the mansion-house is seated upon it, and its

* The height of the table-land round Rouen was thus approximately ascertained:—

| | Feet. | In. |
|---|---|---|
| Base of tower of the cathedral above high water in the harbour, by rough levelling, | 42 | 8 |
| Height of masonry of the tower, 282 Fr. feet = | 300 | 5 |
| Height from this level to top of the country, by rough levelling, | 202 | 8 |
| | 545 | 9 |




escarpment is laid out in a terraced garden. There is, indeed, an exactness of resemblance between this

TERRACE AT VAL DE HAYE, ON THE SEINE.

object and the terraces along the rivers and inland seas of Scotland, which cannot fail to strike every beholder. At Berville sur Mer, on the left side of the embouchure of the river, a terrace several miles long

TERRACE AT BERVILLE SUR MER, ESTUARY OF THE SEINE.

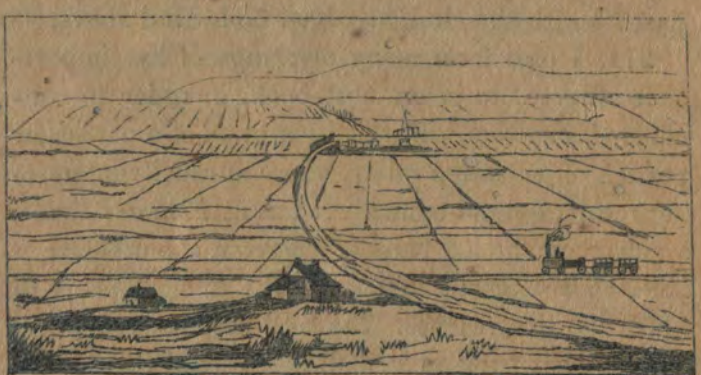
is presented—the more striking, as it forms a perfect parallel with the straight-edged table-land above.

271. I pass from many markings of less importance adverted to in my note-book, in order to conclude this section with the description of a particular portion of the Seine valley, where unusually interesting results were obtained. It was at *Pont de l'Arche*, a village on the left bank of the river, about eighteen miles above Rouen, and nearly the highest point to which the tide reaches. The land here rises abruptly from the left bank to a small height, and then slopes gently backwards. On the opposite bank there is an extensive haugh, so little elevated that it is occasionally overflowed,—as I infer from seeing arches under

the raised causeway by which the road passes. Beyond the haugh, the hills rise with considerable abruptness.

272. I had been so much struck by the terrace appearances at this spot, while passing in the railway train, that I came back from Rouen next morning to make a particular investigation. It is on the comparatively sloping side of the valley, which rises immediately from the river's brink, that these appearances are presented.

273. In approaching that side of the valley from Rouen, we pass across the great haugh by the causeway aforesaid, and then, crossing the Seine by an ancient bridge, we at once ascend into the village of Pont de l'Arche. While still a mile from the village, we can distinctly see that it is seated on a ter-

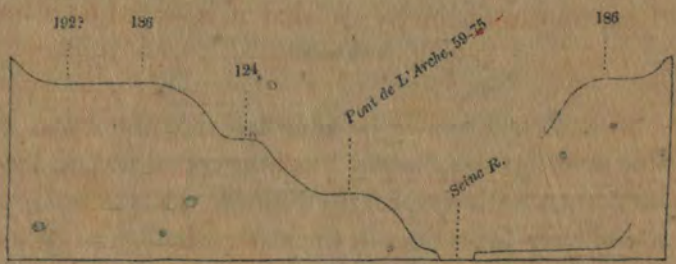


TERRACES AT PONT DE L'ARCHE.

race which stretches a considerable way in each direction. We also observe that the slope above is broken

at what appears half-way up by a second and more strongly marked terrace. Let us take a more favourable situation on the face of the opposite hills, and we see a short terrace faintly marked between these two. In fact, there are here three terraces on one hill-face, a somewhat rare circumstance.

274. And what are the measurements of these terraces? Are they conformable to, or discrepant with, the similar memorials of sea-pauses in Britain? My starting base was on this occasion the surface of the river, at the point to which it seemed to be raised by ordinary tides. The first terrace rose from 59 to 75 feet, the village and its church being seated on the fore part at about the former of these heights. I need scarcely remark how well this agrees with one




of the most prominent of the Scottish beaches. Then, passing up the slope by the road to Evreux, I found the short intermediate terrace—a narrow fragment, but furnished with a good bold escarpment—at about 124 feet; being about the characteristic height for a terrace found in Scotland. Imperfect as this shelf is,

it derives some character from an intersection by a rivulet beside the road; beyond which, we find a small detached piece, bearing a few trees. Let us now pass on to the great superior terrace. On reaching it, we find that it is a vast flat expanse of chalk gravel, covered with a forest; from the front, back to the recommencement of the slope, there is not less than half a mile of ground. A little way onward, when standing clear upon this terrace, our measurement is 186 feet, above which it makes a slight rise inland. This observation speaks for itself. If I am right with the Paris terrace, this at Pont de l'Arche exactly corresponds with it in height, as it also does in lithological character.

## IRELAND.

275. It will readily be admitted that there was, in this investigation, hardly less interest regarding Ireland than with respect to France. I was able to spend very little time in the sister island, and to see but a small portion of its coast; but the results were of a satisfactory nature as far as they went.

276. The valley of the Liffey is occupied from side to side with a detrital deposit of the same character and configuration as that at Preston; a long sloping sheet of transported materials, the accumulation formed by the river, when this valley was occupied

by an estuary, and when the embouchure of the river was at a point now several miles inland. Cuttings in this deposit, at about two miles above Dublin, show, first, beds of sand and gravel; next, a thick bed of blue clay, with stones imbedded. At Lucan, seven miles from Dublin, there is a thick bed of coarse gravel; below this a bed of clay; below that, fine sand. The deposit must fall from a point two or three hundred feet high. It terminates in the midst of the city of Dublin, the rapid slopes in the streets near the Castle being its extremities. As usual, the Liffey has cut for itself a deep channel through the longitudinal extent of the deposit.

277. It was formerly observed that ground rising, as this does, at an extremely low angle, is not well adapted for receiving beach markings. I detected none here, excepting at the lower extremity near the city. There, the sea has made a decided impression when at about 70 feet above its present level, producing the flat in the Phœnix Park where the Wellington Monument is situated, and its continuation across the river at the site of the Kilmainham Hospital. The first reach of the Grand Canal is over this nearly level flooring. It is from 65 to 70 feet above the marking of high water at ordinary tides in the Liffey.

278. At Kingstown, a few miles to the south of Dublin, there is an in-sweeping curve of the high granitic land of the district, backed by the Three

Rock Mountain. It is scarcely using too strong language to say, that this ground is terraced like an amphitheatre. There is also this peculiarity attending it, that a low ridgy hill projects obliquely across the space between the shore at Kingstown and the mountains, and this ridge is terraced on both sides. Thus we have some of the markings doubled, and one of them even tripled, so as to give unusually strong illustration of our subject.

279. Starting from the quay at Kingstown harbour, the markings between that point and the Three Rock Mountain are as follow:—

280. At 64 feet, the flat along which George Street proceeds. It presents itself out of the town to the northward, at from 64 to 80 feet; being there a fine expanse of ground, affording site for Stradbrooke House and other villas.

281. At 107, a flat behind the town, fully a quarter of a mile broad, running up to the bottom of a bank, the top of which appears equally flat.

282. At 139, we come to the top of this bank, and find another distinct flat, stretching far along on either hand, and not less than half a mile in breadth. It is a district of villas, bearing the general name of Glengarry Cross Road. At this place, the level, presented across the Bay of Dublin, takes up a long terrace at the outer extremity of the Hill of Howth.

283. At 165-170, near a place called Cabinteely, we attain the long flat-topped ridge of the intervening

hill before mentioned. Passing along this ridge for a mile northward, and descending on the other side, we come, near a village called Kiln-na-Grange, to a repetition of the flat at 139 feet. Here looking across the vale which intervenes between us and the mountains, the level takes up a shelf on the opposite slope, whereon rests an old church in ruins.

284. The bottom of the valley is an extensive plain, persevering for a great space at 107-112 feet, being thus a varied repetition of the terrace immediately behind the town. Ascending from Dean's Grange in this valley along the slope towards the mountains,

285. We find the shelf with the ruins at (of course) 139 feet.

286. Then passing onward, no other flattening of the ground, or pause in the ascent, occurs, till at 277-288 feet, in the neighbourhood of Fox Rock Cottage, we reach a grand terrace of roughish moorland, with the granite peeping through, which stretches laterally for miles, and extends more than a mile back to the ascent of the Three Rock Mountain. The mansions of Lepardstown and Borton Hall are upon it. From this terrace, the level takes up distant outlines of the country, particularly a long flat sky-line beyond Dublin.

287. It cannot fail to be remarked how well these heights generally correspond with British terraces. We have the 70-feet beach, as it may be called, at

Stradbrooke House. The flat behind Kingstown, and the bottom of the valley at Dean's Grange, coincide with the lowest of the great Meuse plateaux, and the terrace found in so many other situations. The terrace presented at Glengarry Cross Road, at Kiln-na-Grange, and at the ruined church, is slightly below one found at Inverness, the Spey, and other places, and which I have regarded as subordinate, from its comparative rarity. Finally, the grand rough terrace at Fox Rock Cottage is commensurate with one of the most conspicuous of the Scottish beaches, and a magnificent proof of the powerful and long-continued action of the sea-lip at that level.

288. Any other observations made in Ireland tended to confirm the uniformity thus suggested. Proceeding northwards from Dublin, we observe between Baldangan and Skerries a terrace presented seaward near the line of the Drogheda Railway. An outlying mass of it, cut through by the railway, exhibits layers of sand and gravel. This terrace is about 76 feet above the sea at high water.

289. Farther on, at Balbriggan, there is an extensive flat of sandy ground in a moorish condition, which, from its low elevation above the sea, I have no doubt is an example of the kind of plain so well exemplified on the Sussex coast.

290. Near Dunlear, a few miles from the sea, terrace appearances are conspicuous. The flat sandy ground north from the town, seamed as it is by little

water-courses, is unmistakeably an ancient beach. I find from the report of a friend that it is about 66 or 68 feet above high water.

291. The bulk of the town of Belfast is upon a low alluvium at the head of an estuary (the Lough); but a series of streets to the rearward—Carrick-hill, Peter's-hill, Shank-hill—are upon a terrace, which is traceable at intervals along the hill-faces, bordering both sides of the Lough. On the left side, it stretches, in a sinuous but scarcely broken line, as far as Carrickfergus, a distance of fifteen miles. A local geologist reports it as composed of sandstone—lower new red—and having its summit usually covered with beds of tough red clay, with pebbles, and (rarely) shells. At Lepper's Mill, I found this terrace between 60 and 70 feet. On the opposite side of the Lough, it

TERRACE AT BELFAST.

is even more conspicuous, stretching between Belfast and the village of Holywood. It not only presents

the last height at several places, as the villa of Bunker's Hill, and some houses near Holywood, but also a distinct marking at from 96 to 101 feet, and a less equable flat from 20 to 30 feet higher, being the highest surface of this tract of ground. Finally, there is a bench-like piece of ground on the face of the hills, presenting the Stay-brae Meeting-house, and having all the appearances (judging from a distance) of an ancient sea-marking. I am informed that its shelving surface is about 280 feet,—thus conforming to a well-known Scottish terrace.

292. If the east side of Ireland is to be taken as a criterion for the rest, it thus appears that this island has been brought to its present relations with the sea by the same stages as that of Great Britain. The unity of this part of the history of the two islands seems established.

## GENERAL OBSERVATIONS.

293. The preceding local researches and descriptions refer to a space of the earth's surface extending over nine degrees of latitude, and embracing in its breadth the east and west shores of Britain and the east coast of Ireland. They present facts in a great measure new, and lead to conclusions in no small degree at variance with expectation. It can scarcely be necessary for the observer to disclaim responsibility for results as contrary to his own as to any other person's expectations; but he may well be sensible that such results ought to be announced with all due regard to possibilities of fallacy, and with the frankest acknowledgment of all the difficulties which may have been met with, in order that others may judge how far these have been overcome.

294. To a British geologist, who may be familiar only with ancient beaches a few feet above the present sea-level, the first question regarding the many of higher elevation now brought forward will probably be—Are these really memorials of former

levels of the sea? The reasons for concluding that such is actually their character, are for the most part stated in the several cases throughout the past chapters,—their forms as terraces, alluvial plains, indentations, benches, table-lands, lines of hummocks; their being constituted in many instances of stratified sand and gravel (sometimes mixed with marine shells); and their being always truly horizontal in the line of the supposed ancient coast. But true satisfaction on this point is only perhaps to be obtained by rising from the lower and more entire ancient beaches already acknowledged, to others of greater elevation, which only differ in their being somewhat more worn by longer exposure to meteoric agency,—seeing thus the insensible transitions from one object to another, and bringing the utmost limits of variant specific appearances within the sense of a community of character and of history. If authority merely is sought for on the general fact, the British geologist must surely remember that ancient coast-lines, far above any heretofore decided upon in our country, have been described by Scandinavian observers, and that Mr Darwin has traced indubitable markings of the sea in South America to the height of twelve hundred feet. Nor am I unsupported as a native enquirer, for Mr Milne and Mr Maclaren have both described ancient beaches in Scotland of very much greater elevation than any

heretofore observed in England.* Mr Darwin has also professed his belief that the Glen Roy shelves are ancient sea-margins.

295. A second question will be as to the horizontality, continuity, and parallelism of the ideal lines thus traced round our island. These markings are all more or less fragmentary, some occurring in one place, some in another. They have only been examined in a limited number of districts. Nothing

* The various notices of ancient sea-margins in Scotland above 40 feet, published up to the present time, keeping out of view the Parallel Roads of Glen Roy, the character of which has not heretofore been determined, are as follow :—

1. Geognostical sketch of the Great Glen of Scotland. By George Anderson of Inverness. 1821. Wernerian Memoirs, iv., 190. [In this paper, the great alluvial flat behind Inverness was described, but without any surmise of its being an ancient beach.]

2. On the existence of Raised Beaches in the neighbourhood of St Andrews. By R. Chambers, Esq. Edin. New Phil. Journal, Apr. 1843. [This paper contained the first description and measurement of ancient beaches in Scotland at the height of about 70 and 165 feet.]

3. Geological Notes of a Highland Tour. [By Charles Maclaren, Esq.] Scotsman newspaper, Aug. 1843. [The terrace of 100 feet and upwards at Luncarty, and those of superior elevation at Dunkeld and in the neighbourhood of Loch Tay, are here described.]

4. Remarks on Ancient Beaches near Stirling. By Charles Maclaren, Esq. Edin. New Phil. Journal, Oct. 1846. [In this paper, the terrace at Airthrey Well, and several of lower altitude in the valley of the Forth, were described.]

5. On the Parallel Roads of Lochaber, with Remarks on the change of Relative Levels of Sea and Land in Scotland, &c. By David Milne, Esq. Edin., Neill & Co. 1847. [Mr Milne there glances at terraces, eleven in number, which he had observed, ranging up to 750 feet above the sea.]

6. On Ancient Sea-Margins. By Robert Chambers, Esq. Read at the meeting of the British Association at Oxford, June 1847. [The skeleton of the present work.]

like an actual mark girdling the whole range of our coasts can be shown. It certainly is not necessary, however, that any such object should be presented. A series of fragments, of various extent, from a few hundred yards to several miles, found every where horizontal, and every where at one height, seems to afford sufficient evidence on the point. If other fragments are found, as strictly horizontal, and every where at a certain other height, their ideal continuity must be undoubted, while the parallelism of the two lines is mathematically certain. So on as to the rest. Such is actually the description of these series of fragments, as far as their respective elevations could be ascertained. In many instances, the parallelism as well as horizontality becomes tangible, in the presence of a plurality of lines at one place; in which case, the sliding ruler of the geometer could not, to appearance, draw the lines more truly. On these points full light is thrown in the appendix, by tabular summaries of the markings in the various districts; the first exhibiting the numerous examples at and under 545 feet, and the second the comparatively few cases above that elevation. It may be well to state here, once for all, that, in every district, the *whole* of the markings that appeared satisfactory, and of which the elevations could be obtained with tolerable correctness, are given. On the former point, the observer was obliged of course to use his own discretion; it was done, however, under the full conscious-

ness of the check to which his observations are liable, and he trusts that in this respect no fault can be found, though certainly it is not impossible that a second observer might see objects in a somewhat different light from himself, or detect objects which he overlooked.

296. The general appearance of *uniformity* in at least the first of these tables is sufficiently obvious. Let us, however, advert to the difficulties attending this conclusion. *First*, the terraces are so close to each other in some, if not all parts of the vertical space, that it might be thought almost impossible to distinguish them from one another. How easy, for instance, to confound a terrace at 497 feet with one at 513 or 14! How shall we be sure that the 514 feet instance is not the 497 feet terrace raised 17 feet above its original level? This is a challenge very natural for a person newly introduced to the subject, but which would in every case be withdrawn on a better acquaintance with it. Admitting that the levels were all of them describable as close to each other, they are nevertheless sufficiently definite and precise to identify themselves in practical observation. Any one who, in investigating for himself, found terraces repeatedly at 123-8, 141-6, 165-74, 186-95, *but never at any interspace amongst these numbers*, would soon come to acknowledge that the term closeness is of no force in the case. But the fact is, that there are portions of the vertical space to which this term is not applicable,—for instance, between

223 and 280. Another point of importance is the character of superiority or leadership which belongs to some of the markings, as those at about 108, 165, 280, 392, and 545 feet. These are usually on such a scale of breadth and massiveness of material, that the few intermediate ones become comparatively insignificant, and might almost be said to cease to have any place in the problem. There is, even in some of the lower beaches, as those at 43 and 64-70, such a distinctness of character, that, associated though they be, more or less closely, with markings of inferior note and less frequent occurrence, there could be no mistaking them,—I could almost say without the ceremony of measurement.

297. *Second,* May we conclude that the elevations are correctly taken, so as to be sure of the continuity and parallelism? Doubtless, in this particular, considerable difficulties were encountered. That these were entirely or well overcome in all instances I can by no means affirm. The first was to obtain a uniform starting point. In some instances, this was obtained with great accuracy; in other cases, there may be discrepancy to some extent; seldom, however, I should think, exceeding two feet. The second difficulty was to come to a uniform point at the upper extremity of the measurement, for some terraces are comparatively obscure at one part or another of their original form. Here also a difference of one or two feet may be allowed for. Accordingly, the resulting measure-

ments actually are not strictly uniform. I would submit that they are, nevertheless, in all but a few instances, sufficiently so, to leave no reasonable doubt that the markings they refer to are strictly, each in its various parts, coincident. The levels in most of the important instances have been done, wholly, or in part, by professional persons, so as to admit of hardly any doubt of their correctness. In other instances, I have taken them myself by a rough mode of levelling, correcting the experiments by repetition whenever it appeared necessary, and thus attaining to an assurance that a sufficient degree of correctness was secured. It were to have been wished that *all* had been done with authoritative accuracy; but that would have been a process rather for the state, or at least a wealthy society, than for an individual, and I was forced to be content, so far, with only giving immediate satisfaction to my own mind. It is somewhat vexing to consider that by far the greater part of the trouble has lain in this department, and that it is after all, unavoidably, the department most open to correction, though I believe to only an unimportant extent.

298. If it be admitted that these difficulties have been overcome to such an extent as to preclude fallacy, it will follow that the first table presents evidence for an emergence from 545 feet downwards, *uniform over the whole area in question, and attended by at least twenty-five pauses*, of which those at 545,

393, 280, 203-13, 186-92, 165-74, 96-117, and 64-75, were the chief. The evidence in the second table is less forcible for any such conclusion. It is more meagre, because there is less country to be marked at such a height, and the more ancient the marking the less distinct is it likely to be. There is greater divergence from standard sums in the measurement, which may be owing to the greater difficulty attending the taking of heights in inland situations, where data from external sources, whether for inland navigation or railways, had always to be adopted, instead of a direct reference to the surface of the sea. I have nevertheless been as much impressed by what I have seen of sea-markings at about 826, 914, 996, 1024, 1104, and 1135 feet, as by those specified as the most remarkable in the first table. They occur in the north as well as the south of Scotland, and seem to me as powerful elements of the general argument for uniformity as any of the inferior markings. With such facts in our possession, it may at least be said that the unlikelihood of a change of rule at any point in the emergence is very great. On the other hand, it is somewhat surprising that, while there are not wanting appearances of uniformity between the shelf district of Lochaber and the other series of terraces, only one of the signal markings just enumerated as belonging to this range of altitude, is tolerably coincident with any of the four celebrated *Roads*, the most eminent by far of all such

markings in the island. This is a point which must leave a certain degree of dissatisfaction in most minds, perhaps even to the discountenancing of the marine theory for those shelves, although the lacustrine seems to me to be attended by insurmountable difficulties. It may be remarked that, were the elevations of the Glenroy roads 26 feet higher, they would be in better conformity with the terraces of other districts; but, while I am precluded from any suspicion of error in the measurements, the horizontality of these and all other markings, not to speak of the total absence of breaks or faults in the superficial formations, forbids our supposing any inequality of movement. Admitting the difficulty, it appears to me that we must still rest with the idea of a uniform movement for the higher portion of the emergence, as for the lower, at least until some positive evidence for the opposite conclusion shall have been brought forward.

299. The emergence, for which evidence so far has been adduced, and the circumstances of which are now so far explained, clearly refers to the latest section of that long expanse of time with which geology has to deal. It is in the main coeval with the alluvial formations. The time of the *diluvium*, or blue clay, the first deposit over the rocky basis of the land, was immediately antecedent, with its accompaniments of arctic temperature, glacial action, boulder-transportation, and smoothing and scratch-

ing of rock-surfaces. If we may judge from the interplaiting of gravels and sand-beds with the upper portions of the diluvium, in such places as Middleton Moor, the one period was so close to the other, that their characteristics, disturbance and repose, must have had some inosculations in point of time. It would farther appear, from the boulders scattered over the terraces and other alluvial surfaces, as well as from the existence of smoothings and scratchings in limited spaces, irreconcileable with the idea of glacier action, but coincident with former elevations of the sea, that the lower temperature of the diluvial epoch had not been entirely gone during a great part of the currency of the succeeding period.

300. When the sea stood from 1200 to 1500 feet above its present level, as we now feel assured it has done, what was Britain, where subsequently some of the highest questions of civilization were to receive their first solution? An archipelago of mountain islets, extending between Wales and Sutherland. Even when it had sunk to 872 feet, there could be little flat or continental land within its present area. We are called upon, by such vast masses of gravel and sand as occur immediately under this height at Middleton Moor, to admire the great length of time at which the shift of relative level must have been stationary at about that point. The great bank at Middleton, 760 feet above the sea, shows as strongly how long the junction of the two elements continued

at that height. There are similar proofs of very great spaces of time being concerned in many of the inferior markings. We see, for example, at Peebles, a gravel delta delivered there by the Eddlestone water, which could not have been formed in less than many thousands of years, if we can judge from similar works proceeding in the present day. In the hummock at Brecklech in Glenspean, the terrace at Colinton, the plains of Carterhaugh and Philiphaugh, and the great plain of Versailles, we have memorials of an equally long perseverance of the sea at about 393 feet above its present height. And there is not a Highland glen where broken deltas do not tell many such tales.

301. Whatever might be the extraordinary character of the drift or diluvial era, that of the emergence must be regarded as one involving no course of procedure greatly different from that of our own day. The universal equality of terraces certainly shows that no paroxysmal movements of a local nature have taken place in our island during or since that era. The absence of any thing like *faults* in the diluvium is to the same purport. All ideas of debacles, vast currents, wholesale transportation of materials by conceivable and inconceivable means, which still cling like dreams to the minds of some geologists with respect to the superficial formations, vanish. Previously far-carried materials mix of course in the gravels of this era, and a few boulders have been carried, pro-

bably by icebergs, over its seas, and laid on the shores, or dropped elsewhere; but the detrital formations of the time are in the main *local*. The mystery so long resting over the Glenroy shelves, and the debate, whether they were produced by lakes or the sea, may also be said here to approach, if not fully to arrive at, a solution and a settlement. These curious marks appear as only the bite of the sea's tooth in an unusually impressible and tenacious material. *Cols* or heads of glens fall into identity of level with such terraces, only as the result of such a silting up of narrow sounds amongst islands as the Falkland group exhibits at this day. Hummocks and terraces of gravel in high glens are traced to their origin in the neighbouring branch glens, where the detrital agent is still at work: their real character as memorials of the sea which received and deposited the materials, is no longer to be doubted. The arrangement of superficial matters generally in such a valley as that of the Tay,—a low plain of clay near the sea, terraces of sand and light gravel at greater heights farther inland, and still higher masses of heavier gravel farther inland again,—appears readily explicable on the view of the valley being the ancient bed of an estuary, the waters of which were at intervals lowered and withdrawn, the detrital substances of course being always liable to be carried farther in proportion to their lightness. Denudation becomes comparatively an intelligible idea, when now seen more immediately

in connection with the presence of the surface and edge of the sea, in which mainly reside the mechanical force of that fretful element. We also come to have clear and definite ideas regarding a great number of the features in the external configuration of a country and the associations of land and water, over which, simple as they are, much mystery has reigned. Contemplating such features in connection with seas of various depths formerly covering them, we have hardly any difficulty in penetrating their history. Thus, for example, the great glen of Scotland,—occupied at certain parts by profound lakes, at others by isthmusses of gravel,—facts which no cataclyst could look at steadily for a moment,—resolves itself under the present light into a very simple series of phenomena. The origin of a large class of lakes is made manifest. The result of the whole is, I could almost say, majestically simple. It merely unwinds and retraces into the bosom of the past a history such as we could suppose recommencing to-morrow. The superordinary and the vain imaginations of the ignorant mind expelled, there sits the solid frame of at least one considerable portion of the earth, serene and moveless, as if fastened in eternity, with only the traces on its surface, of waters which chafed on it for a while, and then, obeying the resistless commission, quietly withdrew.

# TERRACES AND OTHER MARKINGS IN DISTANT COUNTRIES.

## SWITZERLAND, &c.

302. Mr Playfair remarked the vast quantity of gravel that occupies nearly all the low country of Switzerland. . . The ground, he says, "is never opened in any place, nor an abrupt face found on the banks of a river, where it does not appear that the whole consists of gravel and sand. The gravel consists of the stones which belong to the high Alps, granite, gneiss, mica slate, hornblende schistus, petrosilex, jade, hard limestone, &c. The figure of the stones is worked remarkably true, and the polish in general is fine. The consequence of the rivers running through such materials has been the formation of terraces on a vast scale and in great numbers. In many places a succession of such terraces, as far as five, may be counted; as far as two or three are very common. The height of one above another is from twenty to thirty, and even forty feet. At the Rhine they are very conspicuous; one, of which I measured the perpendicular height, was 122 feet above the pre-

sent surface of the river. When it is considered that three or even four of such terraces can often be counted on the banks of this great river, it may fairly be stated, that the evidence of the Rhine having flowed at the height of 360 feet above the present level is very conclusive."

303. This occurs in the notes on Switzerland in the Life of Mr Playfair, prefixed to his *Works*. The biographer adds—"Even more remarkable than the above are the terraces of gravel upon which the road through the Tyrol is conducted from Sterzing to Inspruck, at a height of 500 feet above the present bed of the river."

304. These detrital deposits have more lately attracted the observation of local geologists, and we now have speculations regarding the superior antiquity of the low alluvia forming the flooring of the vallies, over those constituting the terraces which abut against the sides of the hills, and the oblong ridges which follow the direction of the vallies, after the manner of the *Kames* in Scotland, or with an approach to the character of the Dunipace mounts. It has been stated of the low deposit, that it "corresponds exactly with the deposits brought down by the torrents of the Alps. The predominating rocks are limestones and Alpine sandstones, varied with rolled masses of nagelflue." *

* M. Studer on the Geological Structure of the Alps, 1842. Translated in Jameson's Journal.

There is a difference from the British alluvia in respect of the former; for, while ours contain relics of elephants, rhinoceroses, and other extinct animals, the bones of fifteen living species of mammifora, sheep, ox, fox, rat, weasel, &c., have been discovered deeply imbedded amongst the gravel of the valley of Geneva.*

305. The terraces and other superficial deposits of Switzerland are all at a considerable elevation above the sea. The lake of Geneva stands 1227 feet† above that level. M. Saussure speaks of a plateau of gravel, sand, and clay from 60 to 80 feet above the lake, making in all, when the larger number is adopted, 1312 or 1313 feet above the sea.‡ This terrace appears to be placed in the short space between the bottom of the lake and the opening of the side valley of the Arve, abutting against the hills on the south of the valley of the Rhone. Whether it be identical with the *colline*, as Saussure calls it, or *terrace*, as it is described by others,§ which is said to form the site of the high town of Geneva, I am unable to say. From its situation, however, and its composition of detritus from the

* Pictet, Bibliothéque Universelle de Genève, Aug. 1846.

† Rigidly, 1151·1 Paris feet, according to M. Roger, after a geometrical survey of the Jura.

‡ Saussure, Voyage dans les Alpes.

§ Brewster's Encyclopædia, Art. GENEVA. Saussure speaks of the *colline* as from 80 to 90 feet above the lake, and the Encyclopædia writer gives the same height for the terrace.

Alps, I should expect to find it the ancient alluvium of the Arve, that violent and unruly stream, as Coxe terms it, which here pours into the Rhone the waters which it has brought from the skirts of Mont Blanc. It seems a case precisely analogous to that of the Laire alluvium, by which Loch Treig has been formed, and the Arve may thus be presumed to have been the cause of the lake of Geneva. It is stated that there are appearances of the lake having once reached back to Bex, twelve miles up the valley of the Rhone in the Valais. If these be of the nature of a terrace, it would be worth while to ascertain its height above the lake, and to compare it with that of the Geneva terrace.

306. Mr Smith of Jordanhill has described ancient beaches rising from the sea towards the rock of Gibraltar, constituting the well-known Europa and Windmill Hill Flats; but, unfortunately, he has not stated the heights. Elevated beaches have likewise been described in Greece; and Mr Charles Maclaren tells me that he observed them at various places along the Mediterranean.

### SCANDINAVIA.

307. "In certain parts of Sweden," says M. Durocher, "and chiefly in the elevated regions, such as Dalecarlia, Helsingland, and Jemtland, we find im-

mense plains or very continuous plateau, nearly completely horizontal, and formed of diluvial debris. Sometimes these debris consist of a mixture of sand, gravel, and pebbles, and sometimes of very pure and very fine sand without gravel, and identical with the sand of the shores of the sea; but they frequently present eratic blocks, either at the surface or in the interior. Further, we can ascertain that these two kinds of deposits, the one composed of various kinds of detritus, and the other of pure sand, form alternate zones, which succeed each other, and form a kind of coarse and very undulating stratification. . . . . The presence of these arenaceous deposits and the nature of this sand render the action of water evident."* This description would, in the main, apply well to the similar formations in Scotland.

308. M. Eugene Robert, of the French Northern Nautical Expedition, has supplied descriptions to the same purport with regard to the northern aspect of the Scandinavian peninsula. Near the North Cape, "we have," says the Report in the *Institut*, "representations of many ancient sea-beaches; whose elevation above the present surface of the sea frequently extends to 16 or 24 metres. These ancient beaches are easily known by their perfectly rounded forms, their abraded, and, asit were, polished sur-

* Memoir translated from the Comptes Rendus, in Jameson's Journal, April 1846.

faces, and the mass of broken shells, pebbles, and sea-sand, which cover them at certain places.

309. "At the island of Rolfso-Ham, which is situated between North Cape and Hammerfest, the phenomenon of the progressive rising of Finmark is indicated, in a still more impressive manner, by a great alluvial deposit, which rises, with a gentle slope, to a height of more than 108·7 feet, and showing seven stages or terraces, faintly marked, formed of marine pebbles, placed one behind another, and separated by a turfy soil. The whole of this system rests upon a thick layer of the debris of shells, among which we perceive fragments of *Cyprina Islandica*, and other mollusks, identical with those now living in the Polar Ocean.

310. "It is the same with the island of Qualoe, where M. Robert has, besides, established this singular fact, namely, that in a depression situate behind the gate of the town of Hammerfest, and at a height of about 82 feet above the sea, there exists an assemblage of rounded blocks of the primitive rocks of the country, the interstices of which are filled with small pieces of blackish pumice-stone, similar to those which continue to be thrown ashore from time to time, even in the present day, on the coast of Norway, along with floating wood, and whose origin is evidently to be ascribed to the volcanic eruptions of Iceland, or of that of Jean Mayen."

311. In Spitzbergen, M. Robert found "a formation of marine alluvium, placed above the sea, at heights extending to 128 feet (39 metres), and which is composed of pebbles, gravel, or broken shells, absolutely identical with the deposits daily forming by the waves along the whole bay." *

312. Professor Keilhau has made laborious investigations amongst the ancient marine terraces of Scandinavia. His work not having been accessible to me, I am obliged to adopt the results stated in M. Bravais's Memoirs on the *Lines of Ancient Level of the Sea in Finmark*, where these memorials are assumed as proofs of the upward movement of the land, according to the prevailing hypothesis. It appears, "that not only a strip of coast, but the whole of Norway, from Cape Lindesnæs, to Cape North, and beyond that as far as the fortress of Vardhuus, has been in the course of elevation, during a period immediately anterior to the historic. At the south-east coast, this elevation has amounted to about 200 yards, and the works which denote this ancient line of coast are so nearly horizontal, that the deviation from a level cannot be appreciated—a circumstance that renders it impossible for me to account for the change by assuming a small number of independent disturbances. This main question has,

* Elie de Beaumont's Rapport sur une Memoire de M. Bravais. Edin. New Phil. Journal. Oct. 1841.

partial elevations, of which instances have of late been adduced alike from the coast of Chili and the shores of the Baltic. I must confess, however, to having been struck with great doubt regarding the bearing of M. Bravais's observations to this effect. In the first place, he speaks of the local declination without any remark on its surprising inconsistency with that general horizontality for which proofs have been adduced by Professor Kiellhau, and to which M. Bravais himself subscribes. Then, as to the several pieces of terraces and lines of erosion in Altenfiord, he never intimates of one of them the least decline from the horizontal. On the contrary, he speaks of several of these pieces as "horizontal," "almost accurately horizontal," "a perfectly horizontal line," and in such terms. How strange it seems, if the terraces make a general decline, that out of the six places where they remain distinct, not one should chance to be a place where the presumed declination is observable! Moreover, M. Bravais makes no attempt to explain why the two or three markings of his intercalary terrace do not preserve the proportions of distance from the higher and lower at the two ends of his line of observation; being about right in the middle at the end where the terraces are lowest, and at a very different relative position where they are highest—a fact totally irreconcilable with the idea of these terraces rising as radii from an axis of rest.

316. Under these considerations, I venture to surmise that M. Bravais has fallen into an error which I found very besetting in my own early researches, and above which I was finally placed only by the number and geographical extent of my observations. It is the unexpected multitude of the ancient sea-margins, and the great tendency of each to only a local development, that leads to such errors. We see a beach at one part of the Scottish coast ascending to 85 feet, and some miles off we find another observing a medium level of about 107, and we suppose the one to be an elevated and the other a depressed part of the same terrace, till in time we discover both these beaches *at one place, with a true escarpment between them.* The fact, I think, must be, that, as usual in such situations, the higher Altenfiord terraces are much washed out towards the outer part of the estuary, and only well preserved in the inner and more protected parts. Coming to the outer parts, and still seeing two terraces, the observer might very readily assume that the upper of these was what he had seen uppermost at a higher elevation elsewhere, when in reality it coincided with the lower in the former situation, as it happens to do almost exactly. That M. Bravais was liable to such error, fully appears from an expression of his own. "There can be no doubt," he says, "that the upper line is identical with that of the terraces at Sandfeld and Quænvig, *since no higher line can be traced even on to*

*Quænklubb;* a rock very favourably situated for preserving the indications of the former presence of water." If I had presented observations upon any similar confined district of Scotland, made upon this principle as a basis, the result could have only been a mass of error. In fine, when we cast our eye along the scale arrangement of the whole of the Finmark terraces, and make due allowance for the looseness of the barometrical mode of measurement—when we further remember that in many of the several places a just horizontality has been observed, and that horizontality is the rule throughout the Norwegian coast, we must, I think, be left in a state of utter scepticism regarding the alleged inclination in this little district, if not convinced of the contrary.

317. I have conversed with an intelligent person who was long resident at Alten, in connection with the copper-works there; and from him I learn that there is no such idea prevalent in the district as that the terraces decline. They all appear horizontal, as is indeed not denied, but rather asserted, by M. Bravais. To the same gentleman I am indebted for a remark of some importance regarding these terraces, which coincides with one made by myself elsewhere; namely, as to their beautiful regularity. "That of Quænvig, for example," says he, "is a good half mile in length, and as straight as I have drawn the line with a ruler [alluding to a map which he constructed, with some of the terraces marked; that is to say,

their lines as coasts]. Now," he adds, "you could not find 100 yards of the present strand without irregularities." My friend likewise mentions that, on the removal of the turf from an ancient beach of considerable elevation, at Wadsó in East Finmark (east of the North Cape), pumice was found, "proving not only that this was an ancient beach, but that Hecla was already an active volcano before it was upraised."

318. It appears as if there were a remarkable tendency of the terraces of Norway, as of those of Britain, to run into a certain set of levels. Thus we have, as has been seen, the terrace at Varanger fiord at 206′ 8″, while M. Bravais himself expresses his opinion that it is probably a continuation of his higher line, from which it certainly is not more apart in vertical space, than are several examples of a British terrace, here set down as ranging between 202 and 213 feet, always nearest the lower point where expressed on the most moderately bold ground. M. Bravais refers to a terrace of the same elevation at Tromsöe, and to another example at Logsund, both places many miles to the south and west of Altenfiord, and equally professes his belief that these are other continuations of the same line. Then M. Brongniart found *balani* sticking to the rock at Uddevalla, 206′ 8″ above the sea. If these instances form, as M. Bravais thinks, one sea-marking, it follows that all sea-markings of lower altitude on the coasts whose former position these represent—and

this is a sweep of several hundred miles—must be horizontal also, with detached markings at coincident heights. And what is the fact? There is a terrace at Tromsöe, in latitude 69° 39′, given by M. Siljeström at 147′ 6″, while another at Nord-ostre-fiord, in latitude 60° 35′, and therefore upwards of 600 miles distant from Tromsöe, is 147 feet. Again, Mr Samuel Laing* describes an ancient beach at Fossum (about lat. 64° 20′), at "about 60 feet above the present high water level." Two of the fragments of terrace in Altenfiord are just about this height, and M. Bravais describes a terrace of the same elevation at Pitea on the Gulf of Bothnia.

319. Perhaps, after what has been seen of uniformity extending from the Ness to the Seine, and of these uniformities within the range of a vast extent of sea-board in Scandinavia, it may not be too bold to remark, that there is even some appearance of parity between these two grand groups. Undoubtedly, were a voyager to pass from the Varanger fiord beyond the North Cape, to certain parts of the Scottish coast, he would see the terrace of the one place repeated, as far as elevation is concerned, at the other. Those terraces at 147 feet in Tromsöe and Nord-ostre-fiord, he would find in several parts of Britain. Then a beach for which "60 feet" would appear a good rough description, abounds in

* Residence in Norway.

many parts of the British coast. Four examples are brought forward of more elevated Norwegian beaches or other memorials of the sea. Near Christiania, M. Robert found shells of the *Saxicava rugosa* (a mollusk which lives in water of no great depth) at about 426 feet above the sea: assuming that this is near the height of the former surface of the sea connected with the existence of the shells, we may be said to have a conformable example in Britain, at 442-8 feet. Marine deposits were found on the borders of the Trondheim-fiord at 515 feet, and there are one or two examples in Scotland of a terrace at 520. At the lake of Ozeren, near Christiania, there is a marine deposit at 597, while 596 is the average height of three plateaux of nearly the same level in the environs of Paris. At Trondheim there is another such memorial, 617 feet, which comes near to the height of a distinguished Scottish terrace. Comparatively little can be inferred from these somewhat vague conformities, seeing that an indication of marine deposits does not necessarily lead us with any precision to the height of the associated sea. But it certainly is somewhat startling to find a terrace described at Bardstavig, in latitude 62° 20′, as 656 feet, this being the exact height assigned to one of the more distinguished of the Scottish terraces. We shall recur to this subject after a glance has been taken at the alluvial formations of North America.

## NORTH AMERICA.

320. The evidences of a former high relative position of the sea in this continent, have for some years engaged the attention of the native geologists.

321. "It is well known," says Dr J. L. Riddell, "that, as you proceed inland from the Gulf of Mexico, in Eastern Texas, to the distance of 80 or 90 miles, the face of the country presents a general plain, almost as level as the surface of the ocean. As it is elevated 30 or 40 feet above the tide-water, it is necessarily furrowed by water-courses." This analogue of the Scottish carses is essentially a deposit of sea-sand, identical in all its characters with the sands of the present shores and shallows of the gulf. It contains multitudes of ponds, surrounded by low mounds. "In travelling north from Houston, immediately after crossing Spring Creek, 30 miles distant, we come to a region gently rolling [undulating]," containing pebbles of jasper, quartz, and flint. "The eminences of the rolling region rise from 100 to 300 feet above the valleys. It is evidently of more ancient formation than the level region just described; nevertheless, its outline or contour is obviously the same as when the ocean left it, excepting the narrow gorges, usually from 10 to 30 feet deep, occupied by the present fresh-water streams. Many of the high rolling prairies have their surfaces,

especially their southern declivities, curiously marked with ridges and furrows, five or six feet broad, as though they had been rudely tilled by some former race of giant ploughmen. They have received the euphonical appellation of hog-wallow prairies. Those who have observed the small regular ripple marks impressed by the waves on the sands of a shallow bay, or seen fluted and indented sandstone strata, high, dry, and a thousand miles inland perhaps—the petrified ripple-marks of an ancient sea—will have a correct idea in miniature of the appearance in question. May not these ridges and depressions in the sandy soil be the remains of successive ridges thrown up by the waves of a former sea? If not, whence came they?" *

322. The valley of the Mississippi is a plain equal in extent to two-thirds of Europe, composed of flatly disposed formations, of which the coal measures are the uppermost, thinly covered with soil, and with differences of elevation extending only to a few feet, excepting a few unimportant local inequalities. The north-east corner at Pittsburgh is about 700 feet above tides; the plains of Kentucky and West Tennessee are about the same height; and as we proceed easterly up the Missouri and Arkansas, we reach similar elevations. The river channels are narrow tracks or gutters in this plain, always deep-

* Silliman's Journal, xxxvii. 211.

ening as they go on; hence the large ones seem bordered with abrupt hills of several hundred feet elevation; but the tops of these hills are the level of the great plain, and they only acquire their appearance from the cross sections formed by the tributary streams.* Assuming this description to be correct, the plain of the Mississippi may be regarded as a result of denudation effected by the sea at a little more than 700 feet above its present relative position.

323. All along the sea-board of the United States from Florida to Delaware, there is a more or less broad stripe of low flat land intervening between the sea and the higher grounds, and universally regarded as a tract which the waters have deserted at a comparatively recent period. In Georgia, the low country extends for perhaps 100 miles from the coast, forming what are called the Pine Barrens. Behind this is a country of sand-hills, from 30 to 40 miles wide, extending to the falls of the rivers. In South Carolina, the low tract is not less broad; after which comes a continuation of the Georgian region of sand-hills, "like waves of the sea, for 50 or 60 miles, till you arrive at the Ridge, which is a remarkable tract of high ground as you approach it from the sea, but level as you advance from the north-west." In North Carolina, the low tract extends backward 80 miles, with swamps and marshes interspersed. It is equally

* Hall's Notes on the Western States.

broad in Virginia, extending to the termination of tide water at Fredericksburg, Richmond, &c.; in some places fenny, in others sandy; marine remains every where found near the surface. The higher region is flat at first; afterwards swelling. Similar descriptions apply in part to Maryland.*

324. In a paper describing the tertiary formations of the eastern parts of Virginia, Professors Rogers advert to the external peculiarities of the peninsula called the Northern Neck, between the rivers Potomac and Rappahannock. "The general aspect of the peninsula, and more especially of the four eastern counties, is that of a nearly level plain, maintaining an average elevation of from *sixty to seventy feet* above the tide. This plain, gently furrowed by numerous ravines, subordinate to the creeks and inlets indenting the peninsula, frequently subsides to a lower level, in approaching the rivers on either side. The wide *bench* thus formed, sometimes extends in a direction parallel to the river, for a distance of several miles, presenting an unvarying uniformity of elevation, and reaching nearly to the water's edge. A third and lower plain frequently intervenes between the river bank and the table-land above described; but in many places this terraced configuration of the surface is not observed, and the high and precipitous cliffs which rise very near the water's edge, retain the

* American Atlas, 1827.

general level of the inland portion of the peninsula. Although the usual elevation of this district is such as above described, at several points a far higher level is attained. The ridge which forms the watershed of the streams flowing into the Potomac and Rappahannock, approaching very near to the former, constitutes in some places the river bank. At these points it attains an unusual elevation, towering, as at Stratford and Chantilly, to a height of about 100 feet above the water's edge, and affording from its summit an extensive and enchanting view of the noble river which laves its base, of the cultivated farms around, and of the cliffs on the opposite or Maryland side of the Potomac. At Spring Hill, about 4½ miles from Smith's point, the ridge bends round to the south, and continues for some distance in a direction across the peninsula, preserving an elevation of about 60 feet. Its declivity on the east forms an abrupt termination of the higher level of the rock, between which and the bay shore is an extensive flat, of from two to four miles in width, rarely rising beyond the height of 10 feet above the level of the tide, and in some places so low as to be occasionally overflowed.* . . . .

325. A region south from this, between York and James Rivers, is generally low; "the rest has an elevation above tide, varying from 20 to 80 feet. But

* Transactions of American Society, vol. vi.

few points, however, in the district have a level corresponding to either of these extremes, and by far the larger portion of the surface preserves a height of from 40 to 50 feet." *

326. All the features here described recall perfectly the marks of oceanic action in Britain. Even the elevations—about 10 feet, and from 60 to 70—are of surprising coincidency.

327. The triangular peninsula situated in the southern part of New Jersey, between Delaware Bay and the Raritan, about 110 miles in length by 80 in breadth, is entirely alluvial. According to Mr Pearce —"South of the Nevesink hills, it seldom rises *sixty feet* above the sea. These hills border Amboy Bay, and the entrance of Shrewsbury Creek for several miles, and extend with diminished height to the Delaware. They are elevated adjacent to the sea 310 feet above its level, and occupy ground where formerly the waves of the ocean rolled. They rest in some places on banks of oyster shells and other marine relics, blended with clay and sea-weed." †

328. A striking feature of the American coast is the series of low narrow sandy islets which extends from Florida, with more or less continuity, to Long Island, leaving only a narrow and shallow passage towards the continent, and all of them about 10 or 12 feet high. Sometimes they are upwards of 20

* Transactions of American Society, vol. v.

† Silliman's Journal, vi. 2?7.

miles long, and only a mile or a mile and a half broad. Those towards the north are stated by Mr Mather to be composed of materials derived from the neighbouring cliffs of Long Island. Of Anastasia Island on the Florida coast, the northern portion, and perhaps the whole, is said by Professor Rogers to be "composed of horizontal layers of semi-indurated rock, consisting wholly of fragments of shells, belonging, as far as examined, almost, though not exclusively, to species inhabiting the adjacent coast. . . . . My own conviction," he adds, "regarding these coast-islands is, that they are all portions of a range of shoals or bars formed along the line of junction of the turbid waters from our rivers, and the great insetting currents connected with the Gulf-stream; that since the existence of the Gulf-stream, and the present drainage of the American plain, this growth of sediment opposite the coast has been going on; that in the more tranquil places upon these bars, colonies of shell-fish planted themselves; and that the whole line of shoals has been lifted, with part of the adjacent continent, by the force of an earthquake or earthquakes to their present small elevation above the waves."* The *Kames* of Scotland, the *Eskers* of Ireland, and *Osars* of Sweden, are precisely such formations as these islands would appear, were they lifted above the waves; but we shall see

* Rogers on Geol. of N. America, Brit. Assoc. Report, 1834.

more remarkable examples in the continent now engaging our attention.

329. At Philadelphia, there is one line of houses (Water Street) running along the brink of the Potomac, here a tidal river. Behind rises a high bank, from the top of which extends a flat, on which the plan of the city was originally laid out. "The common notion is, that this terrace was the old bank of the river:"* it is doubtless an alluvium formed by the river when the sea flowed at a superior height, being exactly like formations in Scotland for which no other history can be assigned.

330. Professor H. D. Rogers speaks of ancient alluvia as conspicuous along the American rivers, using not only his own observation, but the authority of various works of credit, some of which mention two, three, and even more, of these river terraces. Professor Hitchcock thus describes them on the Connecticut river in Massachusetts:—"If we start from the edge of the stream at low water, and ascend a bank of 10 or 15 feet high, we shall come upon an alluvial meadow which is frequently overflowed, and is consequently receiving yearly deposits: this may be regarded as the lowest terrace. Crossing this, we ascend the escarpment of a second terrace, 30 or 40 feet in height, which may be seen at intervals on the same level on all sides of the

* Weld's Travels through N. America, 1799.

meadow. This second terrace is rarely very wide in any place, and seems to be only the remnant of a meadow once much more extensive, which has been worn away. Ascending this from 40 to 50 feet up another escarpment, we reach the plain that forms the bottom of the great valley of the continent: this constitutes the upper terrace." He adds, that terraces, more or less distinct, exist on almost every stream of considerable size in the state, wherever the banks are low enough to admit of alluvial flats.

331. At West Point on the Hudson river, there is a gravel formation which Mr Mather gives as 188 feet above the ocean level.

332. We shall now advert to a few detached facts respecting the lower portion of the great St Lawrence basin. On the Mingan islands, towards the north shore of the St Lawrence Gulf, Captain Bayfield traced "a succession of shingle beaches, the most distant from the shore being *sixty feet* above the level of the highest tides."—"In the Bay of Seven Islands, and in almost every other bay, and at the entrance of the valleys near the sea, he observed parallel ridges of sand, sometimes attaining a height of 100 feet, and occasionally containing shells analogous to those now inhabiting the St Lawrence." *

* Geol. Soc. Proceed., Nov. 1833.

333. At Malbay, 90 miles below Quebec, there is a secluded valley, called the valley of St Etienne, watered by a stream which falls into the St Lawrence. Dr Bigsby* describes the sides of this valley as presenting terraces at different heights, composed of alluvial matters, but much cut down by water-courses. By the eye, he estimates the lower ones as ranging between 20 and 80 feet; the upper one is from 300 to 400 feet. In the uplands to the east, about 500 feet above the present bed of the river Malbay, there is "a flat and uniform embankment extending the whole length of the valley, abraded at intervals by torrents. At a certain distance below this range, another is situated, parallel, and marked with corresponding beaches. It declines rapidly, and is succeeded by broken ground, &c. The west side of the valley exhibits the same appearance in the steep bank of alluvium, 400 or 500 feet high, resting on the Middle Hill. This answers to the highest eastern level, and is followed by inferior terraces, although much disturbed and degraded." These observations, from their recalling the same class of objects in Scotland, appear to me exceedingly interesting; and I much regret that no American geologist has yet furnished exact elevations of the Malbay terraces.

334. At Quebec, where the river is still affected

* Silliman's Journal, v. 205.

by the tide, there is, as is well known, a quay and low town, little removed above the waters, and a high town, extending along the Abraham heights, on a portion of which the fort is situated, and which are generally about 200 feet above the sea-level. On the road from the city to Indian Lorette, there is a form of ground, called in America a bluff, of which exact measurements were lately taken by Mr G. R. Baldwin, C. E., while engaged in the works necessary for supplying Quebec with water. A section of this bluff, following a straight line bearing about N. 50° W., has been sent to me by Mr B. Silliman, junior, and its features are exceedingly remarkable. There is first a terrace, measuring in vertical height above spring-tides, in the St Lawrence, from 33 to 40½ feet, above which a stronger slope begins, gradually becoming more steep, till it reaches the frontier of a second terrace. This extends backwards 990 yards, ranging in height above the same base between 64 and 76 feet (sinking fractions), the lowest part being about third way back from the fore-edge. The surface of the lower terrace is stated to be composed at one place of hard clay and sand, and to be at another strewn with boulders. Clay and boulders are also indicated on the second. A steep escarpment backs the latter terrace, and then commences at 135 feet a third terrace, which, extending nearly a mile, rises in that space equably to 193 feet, at which point the section

terminates. Had this section represented the surface of a piece of ground on any British coast, it would certainly have appeared to me exactly such as might be expected.

335. Mr Lyell describes the town of Montreal as placed on a terrace of gravel, from 10 to 20 feet above the St Lawrence, which being here 21 feet above the sea,* the full elevation must be a little above 40 feet. "At the base of the hill [Côte de Neige], on its east side, in the suburbs of Montreal, we find clay and sand above 100 feet deep, in which marine shells occur. This deposit forms a terrace, which ends abruptly in the steep bank facing the river plain, and running parallel to it for three or four miles. It varies in height from 50 to 100 feet." This terrace in some places slopes in towards the hill—a feature observable in many examples of ancient beaches in Britain (for example, that at Chicham, in Sussex, § 256); the inequality must be owing to wearing in certain parts, and the greater sum may therefore be regarded as the true height. If the river be the basis assumed, the entire height above the level of the sea will be about 141 feet. In a hollow between the two eminences which form the Côte de Neige, there is a bed of gravel six feet thick, containing numerous valves of recent species, and covered by an unstratified mass of boulders, twelve

* Bouckette.

feet thick. The bed of shells is estimated at 540 feet above the sea.*

336. The upper part of the course of this grand collection of waters is, as is well known, through great elevated basins of flatly-disposed Silurian strata, the lower hollows of which are filled with lakes, while the sides rise at a gentle rate of inclination, till we reach the broad flat summits, descending in the one direction towards the great plain of the Mississippi, and on the north towards the basin of the Ottawa river, and to certain smaller lakes, of which Simcoe is the chief. This district presents some memorials of ancient sea-levels, which are not, perhaps, exceeded in interest in any part of the globe. To the north of the lowest lake, Ontario, which is 232 feet above the ocean-level, the gentle slope, composed of a deep bed of clay, inclosing scratched boulders, is traversed lengthwise by a series of ridges, nine in number, at a rising series of levels, and several of the uppermost of which are repeated at corresponding levels on the opposite slope descending to Lake Simcoe. In travelling from Toronto, the first is encountered at the distance of a mile, its base 108 feet above the lake, and the ridge itself from 20 to 30 feet high. Its top is composed of sand. A mile and a half farther inland occurs the second, ascending to the height of from 50 to

* Lyell's Travels in North America.

70 feet, from a base 208 above the lake, and having a few boulders over it, and many deposited at its foot. The local geologists affirm that these singular mounds pursue a perfect level, not merely for several miles, but as far as they have been traced, and even to the slope above Lake Erie. Mr Lyell says, "On tracing the ridge for several miles east and west, I occasionally found it to vary greatly in height above the plain, and sometimes to divide into two; one of these sometimes formed a step immediately above the other, and sometimes diverged or branched off, so as to form an upper and parallel ridge at some distance. They are all broken occasionally by deep narrow gaps, as I had observed in the osars of Sweden." He adds—"with the exception of the parallel roads or slopes in Glen Roy, and some neighbouring glens in the Western Highlands of Scotland, I never saw so remarkable an example of banks, terraces, and accumulations of stratified gravel, sand, and clay, maintaining, over wide areas, so perfect a horizontality, as in this district of Toronto." Mr Lyell regarded them as referable, "some to ancient beaches and lines of cliff formed on the margins of channels of the sea; others, including some of the loftiest ridges, as having originated in banks and bars of sand, formed not at the extreme edge of a body of water, but at some distance from the shore, in proportion as the

water attained a certain degree of shallowness from the upheaval of the land."

337. The heights of these ridges above the lake have been given by Mr Roe, civil engineer;* and I repeat his measurements, with the addition of 232, in order to attain the elevations above the sea.

| | |
|---|---|
| A. . . . . | 342 |
| B. . . . . | 442 |
| C. . . . . | 514 |
| D. . . . . | 542 |
| E. . . . . | 576 |
| G. . . . . | 654 |
| L. . . . . | 914 |
| O. . . . . | 996 |

338. Additional memorials of the former presence of the sea are obtained on the south side of Ontario. From the Genessee river, near its mouth, to Lewiston, on the Niagara river, there is a ridge with a general altitude of 30 feet above the neighbouring land, 160 above the lake, or 392 above the sea. A second and parallel ridge is formed twenty miles farther south.†

339. On Goat Island, above the falls of Niagara, and at corresponding elevations on the borders of the river, there are deposits of the nature of an ancient beach, but supposed, from the fresh-water

* Natural History of New York.

† American Atlas, 1827. Hinton's United States, ii. 483.

remains found in them, to have been a former border of a lake. It is, however, remarkable, that the elevation of this deposit above the sea, 538 feet, is nearly the same with that of the Ontario ridge D. There are near this spot indications of an ancient beach, sloping up from the same height to a point 6 feet higher, so that the highest point (544) comes to only about 2 feet above the ridge. There are also at this spot fragments of three lower terraces, respectively about 513, 523, and 530 feet above the sea.

340. Lake Erie is 565 feet above the sea. At Point Abineau, near the east end, there are mounds of sand extending northwards back from the lake, and arresting attention by their massive height, which is not less in some instances than 100 feet. "In general they are of irregular form; but in some places of the greatest altitude, they are so even and straight, that it appears as if they had been thrown up by the hand of art, and you may almost fancy them the old works of some vast fortification." *

341. Along the south shore of Lake Erie, there is a range of terraces and ridges of similar character to those skirting Lake Ontario. They are described by Colonel Whittesley as, in Ohio state, ranging back from the lake between a quarter of a mile and five miles, and being in altitude from 90 to 120 feet above the lake, or from 655 to 685 feet above the

* Weld's Travels through North America, 1799.

sea. In the town of Cleveland, which is close to the lake, the court-house is stated to be on "an ancient beach," 659 feet above the ocean. Mr Hall (*Geology of New York*) speaks of a ridge along Lake Erie, at the height of about 150 feet from the lake, (that is, about 715 above the sea), containing fresh-water shells, and fragments of decayed wood. Whether this be a ridge distinct from those described by Colonel Whittesley, we are not informed; but the various level would seem to say so. Towards the westward, "the terrace and ridge of an ancient beach recede from the lake far into the interior, showing bays up the valleys of all the principal streams, but parallel in its general trend to the Mawmee river." The Mawmee enters the lake from the south-west; beyond it, in the state of Michigan, there is a similar "beach and terrace, 60 miles in length, at a distance of 20 to 25 miles from the lake, and about parallel to the west end of the lake and the Mawmee river." Mr Hubbard gives this as 107 or 108 feet above the lake; consequently 671 or 672 above the ocean.* It therefore probably corresponds with one of those near Cleveland. Mr Lyell inspected some of these Erie terraces, and found them every where observing one level. Like the lake ridge of Ontario, they are all used as public

* Nat. Hist. of New York: Geol. by Mather, p. 152.

roads, for which their levelness, and perhaps also their dryness, render them well qualified..

342. On the higher lakes, St Clair and Michigan, there are deposits indicating the former presence of water at various points of elevation; but we have not as yet very clear accounts of these formations.

343. The various basins of this region are divided from each other by flat summits, the heights of which become of some importance when we remember the connexion between cols or heads of glens in Scotland, and former levels of the sea. That between the Ottawa and the St Lawrence is ascertained by the Rideau Canal which crosses it, as 392 feet above the sea; being thus identical in elevation with the Genessee ridge. The summit between Lake Ontario and Mohawk valley is given as 400 feet; that between Lake Erie and Lockport at 590½; the summit west of Chicago on Lake Michigan 595; between Lake Michigan and Illinois 657; the portage of Wisconsin 699. There are here some approaches to coincidence, of which notice will afterwards be taken.

344. The Geologists of the United States seem to entertain no doubt as to the evidence now adduced being sufficient to prove the former submergence of a large portion of the American continent, and its being raised in mass at what they term the Quaternary Period, "without any great alteration of the relative levels of the different parts, where minute

examinations have been made, while the absolute elevation above its former level must have been from 500 to 1000 feet."* As to the horizontality of the shift, it seems to be perfect throughout the ridge district in Canada, and the New York and Ohio States. There is here proof that, in that shift, from near a thousand feet, down to the present sea-level, the movement, whatever it was, has been *constantly equable*, — a result precisely conformable to that obtained in Scotland, from at least 1200 feet downwards. Throughout the northern part of the American Continent, there is similar proof regarding a lower portion of the vertical space; for, had there been the least divergence from the horizontal, in the last shift in that region, it must have caused the low flat which borders the coast to be presented on an inclination,—a feature which could not have failed to be detected, if it had existed.

345. It does not seem to have occurred to the American geologists to compare elevations at one place with elevations at another, in order to ascertain if there were any parity between them. Yet we have seen that there are several coincidences,— one certainly not a little remarkable in the shell deposit at Montreal, the ridge D on Ontario, and the ancient beach at Niagara falls, all being between 540 and 544 feet. The exact coincidence of the Lake

* Nat. Hist. of New York: Geology, part i. p. 25.

Ridge, to the south of Ontario, with the broad summit of the country between the Ottawa and St Lawrence—both 392 feet—is also remarkable. Other conformities are worthy of some notice, though less striking, as between the Ontario terrace G (654 feet), and the terrace at the court-house of Cleveland on Lake Erie (659), while the summit of country between Lake Michigan and Illinois is 657. It is a pity that more elevations have not been given by the local geologists, since they thus show a tendency to run into parity; it were particularly desirable that we possessed the exact heights of the remaining ridges to the south of Ontario, and of those on Erie and the higher lakes.

346. There is nevertheless enough to justify a question regarding uniformity of level, not only throughout North America, but also—bold as the idea may, in the present state of knowledge and of hypothesis, appear—between the old and the new continents. It has certainly appeared to myself as, to say the least, a promising prognostic of some important new views regarding a chapter in the past history of the globe, when, it being granted that terraces and benches of land are marks of ancient levels of the sea, I find that a tendency to a bench form or plateau, at 60, or from 60 to 70 feet above present high water, exists on the coasts of the United States and in the Gulf of St Lawrence, as it does in Britain; that conspicuous terraces in Britain and in France

at 188 and 392 feet, are repeated in America; that there, also, at about 545 feet, are several repetitions of a decided and most notable Scottish terrace—that Scott built his house of Abbotsford on an ancient sea-beach beside the Tweed, which finds an analogue in the first of the grand ridges sweeping from east to west behind Toronto; and that the sandy plateaux of Lanark and Carstairs are in metrical harmony with the terraces and ridges of the half-peopled wilds of Michigan. Even so high as between nine hundred and a thousand feet above the present sea, there is a parity; and we can hardly say any thing but a parity, when the fact is that the only two ancient American sea-levels given for that space, stand in the following apposition to the Scottish markings within the same space:—

| | Ontario terraces. | Scottish terraces; various districts. |
|---|---|---|
| O. | 996 | 996 . . . 999 |
| | | 958-69 |
| | | 937-8 |
| L. | 914 | 907-14 |

It seems scarcely admissible that accident can have ruled these conformities, arrived at by observers in no correspondence with each other. And perhaps even a more perfect uniformity in the Scottish series might have been attained, if a severe mode of measurement had been more generally attainable.

347. To this memoir are appended tables on a vertical scale, to show the whole series of relations between the leading and more distinct terraces of America, Britain, France, and Norway, which have as yet been observed, and the elevations of which are given with any degree of care. They will serve better than eloquent discourse to show how likelihood lies with regard to uniformity in the shift, over the north of Europe and of America. The tendency of belief, as is well known, has for some years been such as to make inequalities in the shift over even much smaller areas more to be expected as results; but one who goes to the actual objects must take such response as they give, whatever that may be, according to the best of his judgment. After all, the grounds on which the extreme mobility of the surface, as regards the more recent epochs, has been raised into a doctrine, are partial and local. There may have been uprises in Chili, and there may be a constant slow upheaval on the north coast of the Baltic, as is now generally believed, without necessarily inferring that the desertion of ancient sea-margins over whole continents has been a result of precisely a similar movement. One cause may have led to this desertion over vast areas; while another and minor cause, possibly, however, connected with the first, may be now producing elevations of the land in a few scattered districts. On consulting Mr Darwin, to whose kindness throughout the whole of this investigation I feel

much indebted, I find that he can adduce no recent uprise preserving equality over a wide surface, but, on the contrary, believes that such uprises as those of South America which he has described, must present inequality—although, he adds, that to find extensive equality any where, would not change any of his present views regarding elevation. In my judgment, if modern uprises are attended by inequalities within a narrow range of territory, it might be expected that ancient uprises would be so likewise; and when, looking to actual shifts of relative level in ancient times, we find not inequality, but equality, over wide spaces, it becomes almost an irresistible necessity, with those who seek only for truth, to speculate on a different explanation.

348. Perhaps we should be in a more hopeful course, if we were to turn our eyes to Mr Darwin's views regarding the subsidences of great oceanic basins, as implied by the phenomena of coral islands. The undoubted effect of such extensive subsidences must be the lowering of the sea round all the shores of the world. The sinking of an area measuring the twentieth of the aqueous surface of the globe, to the extent of half a mile, would cause a sinking of the entire sea to a depth embracing several of the intervals of our British terraces—about 130 feet. Such may have been the history of the changes of relative level in our region, while, in other districts, both risings and fallings of the land may have taken

place, and may be taking place at this day. There are, it will be remembered, clear proofs that the sea, after falling, had risen again in our island.

349. The recession, accession, and second recession of waters indicated here, do not necessarily imply risings and fallings of our island, but may be accounted for if we suppose some distant ocean bed sinking, then rising, then sinking again. Perhaps it may be some such latent change which has produced those immersions of forests, and those wearings of coasts, with which English geologists are familiar. I feel at least a peculiar difficulty in admitting partial subsidences of land in the British islands, when I see such uniform terraces around their coasts, as, in that case, deflections from the true lines ought to have been conspicuous, which I am sure they are not.

350. Before concluding, I would make a few remarks on the chronology of the ancient beach-markings. The general effect of my researches in this line has been to convey an overpowering impression of the vast space of time concerned in this last group, as it may be called, of geological transactions. Let any one study the remains of the huge detrital accumulations brought down by ancient rivers, such as the Ribble and Liffey, and let him look at the deep channels subsequently cut by the rivers in these masses; let him cast his eye over a great gravel province like that of Moray, and conceive all the modi-

fications which it has undergone since its deposition; let him examine such cuttings into hill-faces as the sea has effected at Birkenhead, such shavings down of districts as it has performed at Chester; and he must believe that very great lapses of time have passed since the sea stood at our highest terrace. In several places in Scotland, I have found the points or promontories of terraces bearing the faint markings of forts which had been erected by our savage forefathers for their protection. History scarcely hints at the age of these remains, so lost is it in the long night of antiquity. But, great as is the time that has elapsed since these rude defences were erected, it is nothing to what seems requisite for producing the phenomena now under our attention. When, moreover, it appears that the species of shell-fish have not changed in this immense series of milleniums, a new and highly interesting consideration arises. Species had, in earlier times, undergone repeated changes. If each change was attained in a lapse of time equal to or greater than that here shown to have passed without any such change, what a vast multiple of this part must be the entire cosmical chronology!

# APPENDIX.

## TABLES,

SHOWING THE HEIGHTS OF TERRACES, &c.,

IN VARIOUS PLACES:

I. TERRACES AT AND UNDER 545 FEET.

II. TERRACES ABOVE 545 FEET.

A few terraces which are as yet unique, or nearly so, are introduced subordinately in small type. Those marked with an asterisk are examples obtained since the preceding sheets passed through the press.

## I. Terraces at and under 545 feet.

| | | Basin of Tay. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Dundee and Carnoustie. | Bambrioch and Balmerino. | Errol. | Perth and Kinfauns. | Mickleour. | Dunkeld, Blair, and Taymouth. |
| 27 | 545 | | | | | | |
| 26 | 530–4 | | | | | | |
| 25 | 514 | | | | | | 497 |
| 24 | 497 | | | | | | |
| 23 | 463–6 | | 466 | | | | |
| 22 | 442–48 | | | | | | 385 |
| 21 | 385–93 | 389 | | | | | |
| | 372–7 | | | | | | |
| 20 | 342–8 | | | | | | |
| 19 | 325 | | | | | | |
| 18 | 306 | | | | | | 279–92 |
| 17 | 280— | | | | | | |
| 16 | 243 | | | | | | |
| 15 | 217–23 | | | | 203 | | |
| 14 | 202–13 | 208–13 | | | | 186 | |
| 13 | 186–93 | | | | | | 165 |
| 12 | 165–74 | | | | | 146 | |
| 11 | 141–6 | 140 | | | 128 | | |
| 10 | 123–8 | | | | 95–117 | | |
| 9 | 96–117 | | | | 85 | | |
| 8 | —90 | —93 | | | | | |
| 7 | 64–75 | | 60–70 | | | | |
| 6 | 56 | 56 | 56 | 56 | 53 | | |
| 5 | 44 | | | | 28— | | |
| 4 | 32 | | | | | | |
| 3 | 27 | | | 20 | | | |
| 2 | 20 | 20 | | | 6–10 | | |
| 1 | —11 | | | | | | |

## I. Terraces at and under 545 feet.

| | | Stratheden, Fifeshire. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Leuchars. | St Andrews. | Dairsie, Ceres, and Teasses. | Falkland. | Kettle-hill. | Tarvit Hill. |
| 27 | 545 | | 545 | 545 | | | 543 |
| 26 | 530–4 | | | | | | |
| 25 | 514 | | | 514 | | | |
| 24 | 497 | | | | | | |
| 23 | 463–6 | | 465 | 465 | | | 466 |
| 22 | 442–48 | | | 442 | | | |
| 21 | 385–93 | | | 386 | | | |
| | 372–7 | | | | | *376 | |
| 20 | 342–8 | | | 345–8 | | | |
| 19 | 325 | | 325–30 | | | | |
| 18 | 306 | | | | | | |
| 17 | 280— | | 280–93 | | | | |
| 16 | 243 | | | | 243 | | |
| 15 | 217–23 | | | | | | |
| 14 | 202–13 | | 203 | 203 | 203 | | |
| 13 | 186–93 | | | | | | |
| 12 | 165–74 | | 165 | 170 | | | |
| 11 | 141–6 | | | | | | |
| 10 | 123–8 | | 126 | 128 | | | |
| 9 | 96–117 | 107 | —117 | 107 | | | |
| 8 | —90 | | | | | | |
| 7 | 64–75 | 70 | 64–70 | 64 | | | |
| 6 | 56 | 56 | | | | | |
| 5 | 44 | | | | | | |
| 4 | 32 | | | | | | |
| 3 | 27 | | | | | | |
| 2 | 20 | 20 | | | | | |
| 1 | —11 | | 11 | | | | |

## I. Terraces at and under 545 feet.

| | | Moray. | Inverness-shire. | | | Basin of Forth. | |
|---|---|---|---|---|---|---|---|
| | | Lossiemouth, Elgin, and Fochabers. | Inverness, Dochnacraig, and Fort-Augustus. | Fort William. | Glen Spean. | Kirkaldy. | Markinch, Leslie, and Kinross |
| 27 | 545 | | | | | | |
| 26 | 530–4 | | 530 | | 534 | | |
| 25 | 514 | | | | 520 | | |
| 24 | 497 | | 497 | | | | 497 |
| 23 | 463–6 | | 461 | | 446 | | |
| 22 | 442–48 | | | | 428 | | 448 |
| 21 | 385–93 | | | | 391 | | 385–9 |
| | 372–7 | | 377 | | 372 | | |
| 20 | 342–8 | | 344 | | 345 | | |
| 19 | 325 | | | 325 | 325 | | |
| 18 | 306 | | | | | | |
| 17 | 280— | 280 | 279 | 288 | | | 285 |
| 16 | 243 | | | | | | |
| 15 | 217–23 | 220 | 217–23 | | | | |
| 14 | 202–13 | | 205 | 202–13 | 210 | | |
| 13 | 186–93 | | 189 | 187 | | 186–90 | |
| 12 | 165–74 | 165–74 | 165 | 165 | 167 | | |
| 11 | 141–6 | 141–5 | | 144 | 141 | | |
| 10 | 123–8 | 126–8 | 123 | | | 125 | |
| 9 | 96–117 | | 96–117 | 96 | | 100 | |
| 8 | —90 | | | | | 85 | |
| 7 | 64–75 | | | 64–70 | | 64 | |
| 6 | 56 | | | | | 56 | |
| 5 | 44 | | | 43 | | | |
| 4 | 32 | | | 32 | | | |
| 3 | 27 | | 26 | | | 25 | |
| 2 | 20 | | | | | | |
| 1 | —11 | | | | | | |

## I. Terraces at and under 545 feet.

| | | Basin of Forth. | | | Vale of Tweed. | | Dumfries-shire. |
|---|---|---|---|---|---|---|---|
| | | Edinburgh, Portobello, Granton, &c. | Musselburgh and Dalkeith. | Falkirk and Stirling. | Tweedside; range of 30 miles. | Denholm, Teviotdale. | Cannoble. |
| 27 | 545 | | | | 542–5 | | |
| 26 | 530–4 | | | | | | |
| 25 | 514 | | | | | | |
| 24 | 497 | | | | 497 | *494 | |
| 23 | 463–6 | | | | | | |
| 22 | 442–48 | | | | 442–8 | | |
| 21 | 385–93 | 380— | 390 | | •391–3 | | *392 |
| | 372–7 | | | | | | |
| 20 | 342–8 | | | | 346 | *346 | |
| 19 | 325 | 325 | | | | | *320 |
| 18 | 306 | | | | | *306 | |
| 17 | 280— | 280 | 280 | | | | *277 |
| 16 | 243 | | | | | | |
| 15 | 217–23 | | | | | | *219 |
| 14 | 202–13 | 203–5 | 208 | | | | |
| 13 | 186–93 | 186 | | | | | *192 |
| 12 | 165–74 | 165–8 | 168–73 | 165 | 170 | | *165 |
| 11 | 141–6 | 144 | 144— | | | | *144 |
| 10 | 123–8 | 125 | | | 122 | | |
| 9 | 96–117 | —108 | 106–13 | —117 | 108 | | |
| 8 | —90 | 90 | 90 | 91 | | | |
| 7 | 64–75 | 64 | 64 | | 64–70 | | |
| 6 | 56 | 56 | 56 | | 56 | | |
| 5 | 44 | | | 43 | 44 | | |
| 4 | 32 | | | | 30–2 | | |
| 3 | 27 | 26 | | | | | |
| 2 | 20 | 20 | | | | | |
| 1 | —11 | | 10 | | | | |

## I. Terraces at and under 545 feet.

| | | Basin of Clyde. | | West Coast of England. | | |
|---|---|---|---|---|---|---|
| | | Firth of Clyde and Loren vale. | Glasgow, Ruther-glen, and Bothwell. | Preston. | Liverpool, Birkenhead, and Egre-mont. | Chester. |
| 27 | 545 | | | | | |
| 26 | 530–4 | | | | | |
| 25 | 514 | | | | | |
| 24 | 497 | | | | | |
| 23 | 463–6 | | | | | |
| 22 | 442–48 | | | | | |
| 21 | 385–93 | | | | | |
| | 372–7 | | | | | |
| 20 | 342–8 | | | | | |
| 19 | 325 | | | | | |
| 18 | 306 | | | | | |
| 17 | 280— | | | | | |
| 16 | 243 | | | | | |
| 15 | 217–23 | | | | | |
| 14 | 202–13 | | | | | |
| 13 | 186–93 | | 192 | | | |
| 12 | 165–74 | | | | | |
| 11 | 141–6 | | 144 | | | |
| 10 | 123–8 | | 122–8 | 122–8 | 128 | |
| 9 | 96–117 | 108 | | 100 | | |
| 8 | —90 | | —85 | | —85 | |
| 7 | 64–75 | 64–9 | 67–70 | 60–70 | 60–70 | 60–72 |
| 6 | 56 | | | | | |
| 5 | 44 | | | | | |
| 4 | 32 | 27–32 | | | | |
| 3 | 27 | | 26 | | | |
| 2 | 20 | | | | | |
| 1 | —11 | | 11 | 11 | | |

## I. Terraces at and under 545 feet.

| | | West Coast of England. | | Valley of Thames. | South Coast of England. | Valley of Seine. | East Coast of Ireland. |
|---|---|---|---|---|---|---|---|
| | | Bristol, &c. | Bath. | | | | |
| 27 | 545 | | | | | 545 | |
| 26 | 530–4 | | | | | 531 | |
| 25 | 514 | | | | | | |
| 24 | 497 | | | | | | |
| 23 | 463–6 | | | | | 461–5 | |
| 22 | 442–48 | | | | | 440–3 | |
| 21 | 385–93 | | | | | 422½ 393 | |
| | 372–7 | | | | | | |
| 20 | 342–8 | 342 | | | | 347–50 | |
| 19 | 325 | | | | | | |
| 18 | 306 | | | | | 314½ 307 | |
| 17 | 280— | 277–82 | | | 278 | 281½ | 277–88 |
| 16 | 243 | | | | | 263 238½ | |
| 15 | 217–23 | | | | | | |
| 14 | 202–13 | | | | | | |
| 13 | 186–93 | 187–93 | 186–90 | | 185— | 186–92 | |
| 12 | 165–74 | | | | 172 | | 165–70 |
| 11 | 141–6 | | | 145–50 | 146 | | 139 |
| 10 | 123–8 | 128 | 128 | | 128 | 126 | |
| 9 | 96–117 | | | 112 | | | 107–12 |
| 8 | —90 | | | 90 | | | |
| 7 | 64–75 | | | 64 | 64— | 69 | 60–70 |
| 6 | 56 | 55 | | | | | |
| 5 | 44 | | | | —43 | | |
| 4 | 32 | | | 30 | | | |
| 3 | 27 | | | | | | |
| 2 | 20 | | | | | | |
| 1 | —11 | | | | | | |

## II. Terraces above 545 feet.

| | | Fifeshire. | | Inverness-shire. | | | |
|---|---|---|---|---|---|---|---|
| | | Teasses. | West Lomond Hill. | Strathspey. | Dochnacraig, Loch Ness. | Glen Spean and Glenroy. | Glen Gluoy. |
| 57 | 1337–42 | | *1338? | | | 1337 | |
| 56 | 1282–90 | | | | | 1290 | |
| 55 | 1251–61 | | | 1261 | | 1261 | |
| 54 | 1226 | | | | | | |
| 53 | 1196 | | | | | | 1169½? |
| 52 | 1166–71 | | | | | | 1159½ |
| 51 | 1132–9½ | | | 1131 | | 1139½ | |
| 50 | 1125½–6 | | | | | 1125½ | |
| 49 | 1104–7 | | | 1104 | | | |
| 48 | 1073–90 | | | 1075 | | 1089½ | |
| 47 | 1052–9½ | | | 1052 | | 1059½ | |
| 46 | 1023–8 | | | 1028 | | | |
| 45 | 996–9 | | 996 | 997 | | | |
| 44 | 958–69½ | | | | | | 969½? |
| 43 | 937–48 | | | | | | 959½ |
| 42 | 907–14 | | | | | | |
| 41 | 867–79 | | | 867 | | | |
| 40 | 844–53 | | | 853 | | 847 | |
| 39 | 821–9 | | | 829 | | | |
| 38 | 808–14 | | | 808 | | | |
| 37 | 777–87 | | | 792 777 | | | |
| 36 | 758–67 | | 758–60 | 760— | | 760½ | |
| 35 | 728–34 | | | | | 734 | |
| 34 | 703–9 | | | | | 703 | |
| 33 | 675–87 | | | | | 679 | |
| 32 | 656 | | | | | | |
| 31 | 628–30 | | | | 626 | 627 | |
| 30 | 599 | 599 | | | | | |
| 29 | 573–6 | 573 | | | | | |
| 28 | 562–4 | | | | 562 | | |

## II. Terraces above 545 feet.

| | | Loch Tulla, Argyleshire. | Borthwick, &c., Edinburghshire. | Vale of Tweed. | | | Vale of Clyde. |
|---|---|---|---|---|---|---|---|
| | | | | Tweed. | Yarrow. | Denholm, Teviotdale. | Carstairs. |
| 57 | 1337–42 | | | 1336 | | *1342 | |
| 56 | 1282–90 | | | 1282 | | | |
| 55 | 1251–61 | | | | | | |
| 54 | 1226 | | | 1226 | | *1226 | |
| 53 | 1196 | | | 1196 | | | |
| 52 | 1166–71 | | | 1166 | 1186 | | |
| 51 | 1132–9½ | 1132 | | 1133 | | | |
| 50 | 1125½–6 | | | | 1126 | | |
| 49 | 1104–7 | 1104 | | | | | |
| 48 | 1073–90 | | | 1087–8 | 1081 | | |
| 47 | 1052–9½ | | | | | | |
| 46 | 1023–8 | 1025 | | 1024 | | | |
| 45 | 996–9 | | | | | | |
| 44 | 958–69½ | | 968½ | 967 | 958 | | |
| 43 | 937–48 | 948 | | | | *938 | |
| 42 | 907–14 | 907 | | 914 | | | |
| 41 | 867–79 | | 872 | 872–5 | 879 | | |
| 40 | 844–53 | | | | | | |
| 39 | 821–9 | | 821–6 | 829 | 824 | | |
| 38 | 808–14 | 814 | | | | | |
| 37 | 777–87 | | | 787 | 779 | | |
| 36 | 758–67 | | 760— | | | *767 | |
| 35 | 728–34 | | | | | | 728–30 |
| 34 | 703–9 | | 706 | 708 | 709 | | |
| 33 | 675–87 | | 687 | 675 | 685 | *676 | 675–87 |
| 32 | 656 | | 656 | | 656 | | |
| 31 | 628–30 | | 628 | 628 | 630 | | |
| 30 | 599 | | | | | | |
| 29 | 573–6 | | | | | | |
| 28 | 562–4 | | | | | | |

## II. Terraces above 545 feet.

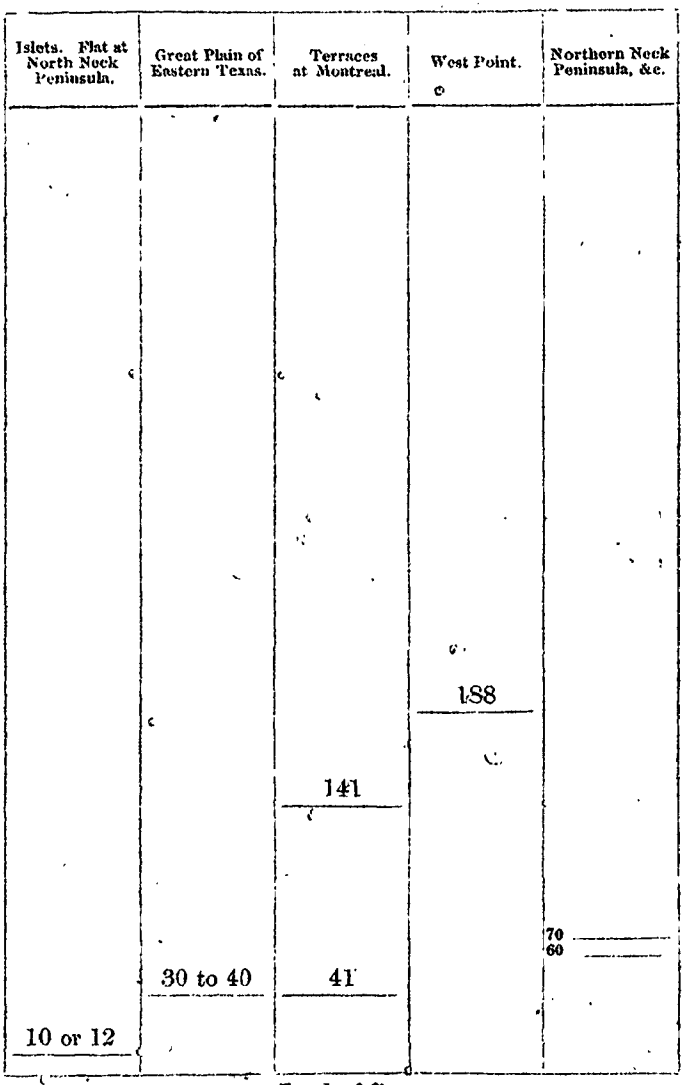
| | Vale of Clyde. | | | Evan vale, Dumfriesshire. | Vale of Allan, Northumberland, and Weardale, Durham. | Valley of Soino. |
|---|---|---|---|---|---|---|
| | Woodend. | Crawford. | Newton. | | | |
| 57 1337–42 | | | | | | |
| 56 1282–90 | | 1286 | | | | |
| 55 1251–61 | | 1251 | | | | |
| 54 1226 | | 1240 | | | | |
| 53 1196 | | | | | | |
| 52 1166–71 | | 1171 | | | | |
| 51 1132–9½ | 1139 | | | | | |
| 50 1125½–6 | | | | | | |
| 49 1104–7 | | 1107 | | | | |
| 48 1073–90 | | 1090 | | 1073 | *1073 | |
| 47 1052–9½ | | | | | | |
| 46 1023–8 | | 1025 | 1025 | 1023 | | |
| 45 996–9 | 999 | | | | | |
| 44 958–69½ | | 962 | 963 | | | |
| 43 937–48 | | 937 | | | | |
| 42 907–14 | | 910 | 912 | | | |
| 41 867–79 | | | | | | |
| 40 844–53 | | 844 | | | | |
| 39 821–9 | | 826 | | | *826 | |
| 38 808–14 | | | | | | |
| 37 777–87 | | | | | | |
| 36 758–67 | | | | | *760— | |
| 35 728–34 | | | | | | |
| 34 703–9 | | | | | | |
| 33 675–87 | | | | | | |
| 32 656 | | | | | | 629½ |
| 31 628–30 | | | | | | 599 |
| 30 599 | | | | 576 | | 576 |
| 29 573–6 | | | | | | 564 |
| 28 562–4 | | | | | | |

# TABLES,

DRAWN TO A SCALE OF 1 INCH TO 100 FEET,

SHOWING THE COMPARATIVE HEIGHTS OF TERRACES IN BRITAIN, FRANCE, NORWAY, AND AMERICA.

## I. Terraces under 500 feet.



## I. Terraces under 500 feet.

| Ontario. | Britain. | France. | Norway. | Spitzbergen. |
|---|---|---|---|---|
| | 461–6 | 462–5 | | |
| 442 | 438–42 | 442–3 | | |
| 392 | 392–4 | 392 | | |
| 342 | 342–8 | 347 | | |
| | 279... | 281 | | |
| 242–7 | 243 | 238⅔ | | |
| | 202–17 | | 206 | |
| | 186-95 | 186–92 | | |
| | 165–70 | 167 | | |
| | 146 | | 147 | |
| | 126–8 | 126 | | 128 |
| | 70<br>60 | 69 | 60 | |
| | 40–4 | | | |
| | 10 or 11 | | | |

*Level of Sea.*

## II. Terraces above 500 feet.

| Summit west of Chicago. | Summit between Michigan and Illinois. | Cleveland Terrace on Lake Erie. | Ridges on Lake Erie. | Niagara Terraces. |
|---|---|---|---|---|
| | | | 715 | |
| | | | 685 | |
| | 657 | 659 | | |
| 595 | | | | |
| | | | | 544 |
| | | | | 530½ |
| | | | | 523 |
| | | | | 513 |

*500 Feet above Level of Sea.*

## II. Terraces above 500 feet.

| Ridges, &c. on Lake Ontario. | Shell deposit on Hill at Montreal. | Scottish Terraces. | Norway. | France. |
|---|---|---|---|---|
| 996 | | 996 | | |
| 914 | | 914 | | |
| | | 709 | | |
| | | 687 | | |
| 654 | | 656 | 656 | |
| | | 628–30 | | 620 |
| | | 599 | 597 | 599 |
| 576 | | 576 | | 576 |
| | | 562 | | 563½ |
| 542 | 540 | 545 | | 545 |
| | | 520 | | 531 |
| 514 | | 514 | 515 | |

500 *Feet above Level of Sea.*

## CORRIGENDA.

P. 93. In section, *for* 34, *read* 43.

147. In section, *for* 25, *read* 225.

158. Fourth line from bottom, for *vertical*, read *detrital*.

326. In the Glen Spean column, 246 is placed a line too high.

JOHN HUGHES, PRINTER, EDINBURGH.

00032974

Digitized with financial assistance from the
Government of Maharashtra
on 10 February, 2016